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# Chesapeake Bay
# A Framework for Action, Appendices

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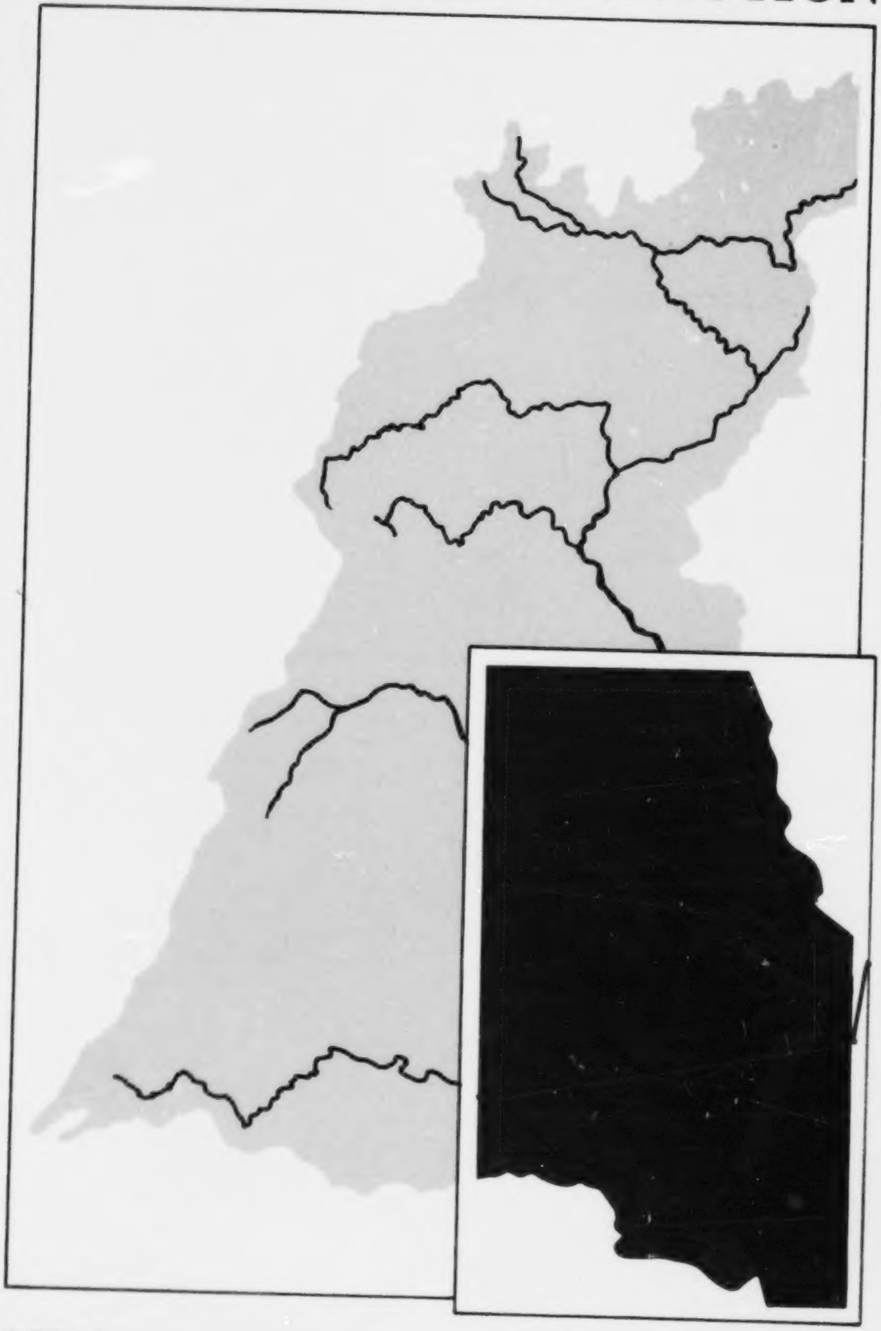
# CHESAPEAKE BAY: A FRAMEWORK FOR ACTION



# APPENDICES

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# CHESAPEAKE BAY: A FRAMEWORK FOR ACTION

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This document includes the seven appendices to the report Chesapeake Bay: A Framework for Action. The report and its appendices describe the state of the Chesapeake Bay, pollutant sources and loadings, and alternative management strategies for improving the environmental quality of the Bay.

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# PREFACE

This document includes the seven appendices to the report Chesapeake Bay: A Framework for Action developed by the U.S. Environmental Protection Agency's Chesapeake Bay Program. The report and its appendices describe the state of the Bay, pollutant sources and loadings, and alternative management strategies for improving the environmental quality of the Bay.

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Robert B. Biggs
David A. Flemer
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## SECTION 1

# INTRODUCTION

Human intervention in aquatic systems must be regulated to protect the environmental quality of waters. The extent to which such intervention is controlled has traditionaly been determined by a combination of technological and use-based controls. The framework discussed here permits the continued use of technology-based controls; however, consideration of use-based controls will be amplified because the need and availabile information indicates that water quality, a surrogate for use designations, is now useful and appropriate for Chesapeake Bay and tidal tributaries.

In the Bay system an effective approach is to emphasize specific environmental quality goals for waters based on the uses desired of them. For example, an oystering area should have different environmental quality goals than a harbor. Quality criteria, where practical, should be related to a range of environmental goals, so that the addition of materials can be tailored to comply with the best uses of the waters. The advantage of this approach is that criteria can be defended for selected materials because they support attainment of specific uses.

Relationships between pollutant concentrations and biological effects in estuaries are not well understood scientifically. Estuaries are complex because of their congruent marine and fluvial influences. As better definition occurs between ecological processes and patterns of observable phenomena, it is anticipated that this proposed framework will provide the basis for evolving what is now a static characterization of ecological relationships into a dynamic framework. However, the present state-of-the-art suggests that simple linear approximations of inherently non-linear processes is a reasonable place to begin the process of data organization. The calculus of an Environmental Quality Classification Scheme (EQCS) must await further scientific understanding of the Bay as an ecosystem (U.S. EPA 1982a; also Appendix F, this document). For this reason, the EQCS is likely to be greatly improved in the future as our scientific understanding increases. Although imperfect, this tool provides guidance for management decisions and suggests areas needing scientific study.

## RATIONALE

Users of the environmental quality classification scheme may infer that attainment of a criterion value will result in meeting its associated objectives. However, attaining criterion values can never assure that environmental objectives will be met because criterion values are analogous to limiting factors. In the same sense that adding nutrients will not stimulate phytoplankton growth if light is limiting, attaining water quality criterion values will not promote development of a desired biological resource if some other factor limits its well-being. Thus, the proper interpretation of water quality criteria is that their attainment will not guarantee that environmental objectives will be met; on the other hand, water quality inferior to criterion values will not support the environmental objectives.

When water quality criteria are developed in association with environmental objectives, the criteria must be seen as a composite rather than as a set of isolated variables. This concept represents a significant advance over our previous notion of criteria as single isolated variables. It is a holistic approach that accounts for the interaction of many factors in supporting biological resources (i.e., an ecosystem perspective).

Criterion values are based on the attainment of a given use. Because of the high salt content in the estuary, the water is seldom considered for drinking purposes, except in the tidal-fresh zone. However, recreation and various fisheries and their supporting food-webs rank high among the traditional uses, especially for Chesapeake Bay and tidal waters. It is in this context that the discussion of the development of a framework for an environmental quality classification scheme will be focussed.

The framework is probably most reliably applied to situations in which the environmental objective is to maintain uses at their existing level or to permit some degradation. These situations are better documented with data. There is less certainty in applying water quality criteria to improve uses because there are less data to describe such situations. It is not known how much time is required for a system to recover once uses have been lost, nor is it known when a system is so degraded that it is technically impossible to restore certain uses to it. The classification scheme is probably most reliable under normal climatic conditions. Effects of extreme conditions and catastrophic events are not accounted for.

## OBJECTIVE

In this appendix, a framework for a classification scheme for nitrogen and phosphorus is developed, relying on the relative difference between segments of the Bay to develop a continuum. Deep-water anoxia in the main Bay is discussed and first order estimates of its importance, biological consequences, and possible causes and controls are offered. For toxic components in sediments, the contamination index developed in the characterization report (Flemer et al. 1983) is used to rank segments against pre-Colonial metal concentrations. In both the nutrient and sedimentary toxic schemes, more emphasis is placed on nutrients as compared to toxic substances because we have more information to relate nutrients to biological efforts. An attempt is made to qualitatively relate important ecological thresholds, but the schemes are not combined.

SECTION 2

# DEVELOPMENT OF A CLASSIFICTION SYSTEM FOR NUTRIENTS

To derive water quality ranks, several analytical approaches were attempted. First, the Vollenweider function (Vollenweider 1968) for each tidal-fresh segment, as well as for CB-1 and CB-2, was computed using historic nutrient loadings (corrected for changing population, point sources, land use, and fertilizer application rate) from 1950 to 1980. Residence time for each segment was computed using plug flow, salt-water fraction, and modified tidal-prism methods. The loads of total nitrogen (TN), total phosphorus (TP), and the inorganic and organic fractions, were regressed against observed concentrations of chlorophyll a, dissolved oxygen (DO), and nutrient concentrations in the respective segments. No statistically significant relations were found and the method was abandoned.

A second approach, involving retrospective analysis of water quality and resources, was attempted. Water quality parameters were correlated against estuarine resources such as submerged aquatic vegetation (SAV), the juvenile fisheries index, and fish landings. When a statistically significant correlation exists between water quality and resources, a causal relationship may exist. These correlations are discussed in detail in Flemer et al. 1983.

Figures 1 and 2 illustrate the kinds of relationships that can be demonstrated between water quality parameters and resources from historical field data (Figure 1) and from laboratory mesocosm data (Figure 2). The problem with a classification scheme based on such relationships is that both the water quality and the resource variables may co-vary with an unknown and uncontrollable variable such as climate. Further, resources may be affected by management practices; water quality may be affected by a change in land use. It was concluded that correlative retrospective analysis can provide only a first-order estimate of the relationship between living resources and environmental quality. The correlations which were obtained could not be inverted; that is, the degree to which improving water quality will restore resources cannot be quantified. Thus, the possible causal relationship must be developed independently of simple correlations before the simple approach can be used with confidence.

The third attempt to develop a classification scheme involved the use of seasonal TN and TP concentrations in the water column as a relative index of water quality. This scheme avoids explicit correlations between water quality parameters and resources, yet permits qualitative comparisons between them. Thus, a tidal-freshwater segment might be classified as "Patuxent-like" or "Rappahannock-like" on the basis of nitrogen or phosphorus concentrations. The approach assumes that major system features (i.e., flushing time, sediment type, tidal-marsh development, etc.) approximate each other between the tidal-freshwater Patuxent and Rappahannock River segments.

Total nitrogen and total phosphorus concentrations have long been used as indicators of environmental quality in aquatic systems (Jaworski 1981). The CBP attempted to evaluate estuarine water quality on the basis of N and P concentrations and the N/P (atomic) ratio, as illustrated in Figure 3.

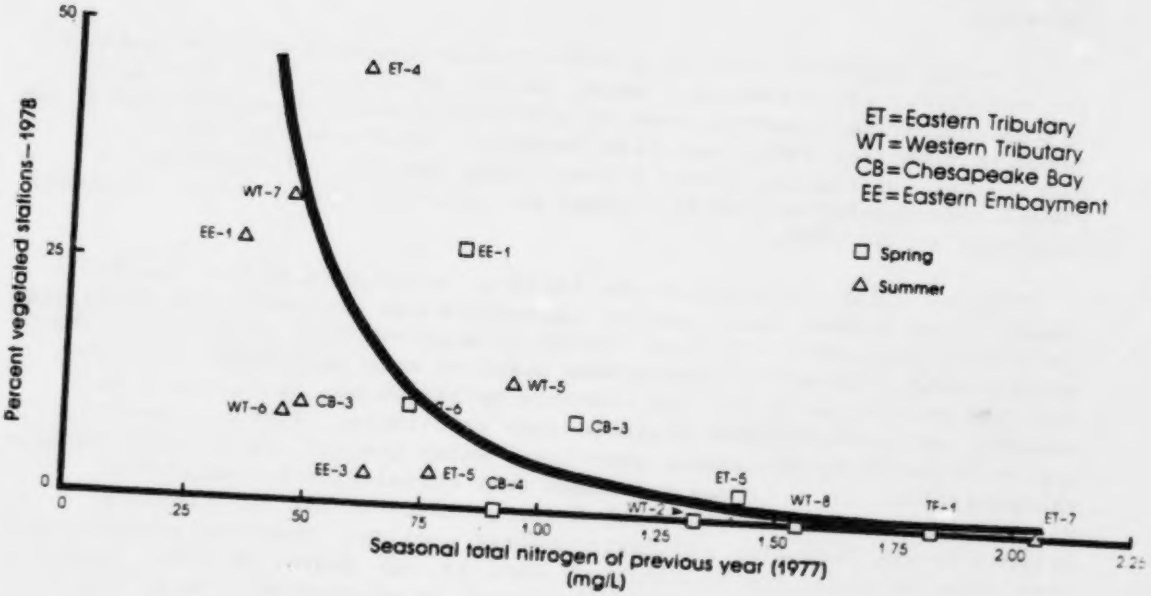

Figure 1. Correlation between percent vegetated stations and annual total nitrogen of previous year.

# NUTRIENT LOADING EFFECTS ON MACROPHYTE BIOMASS

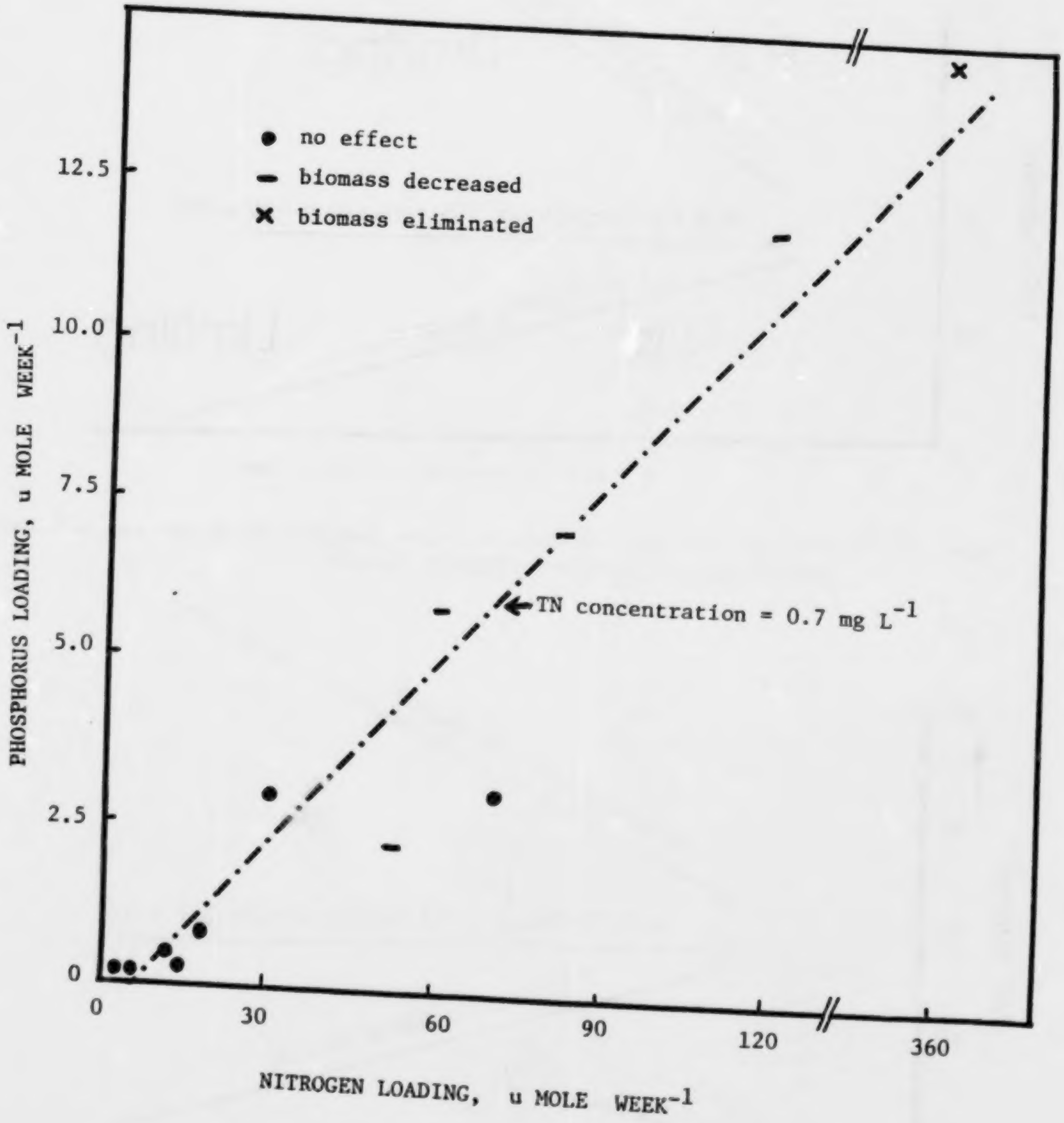

Figure 2. The response of submerged aquatic vegetation in experimental ponds to various loading rates of nitrogen and phosphorus (Kemp et al. 1982).

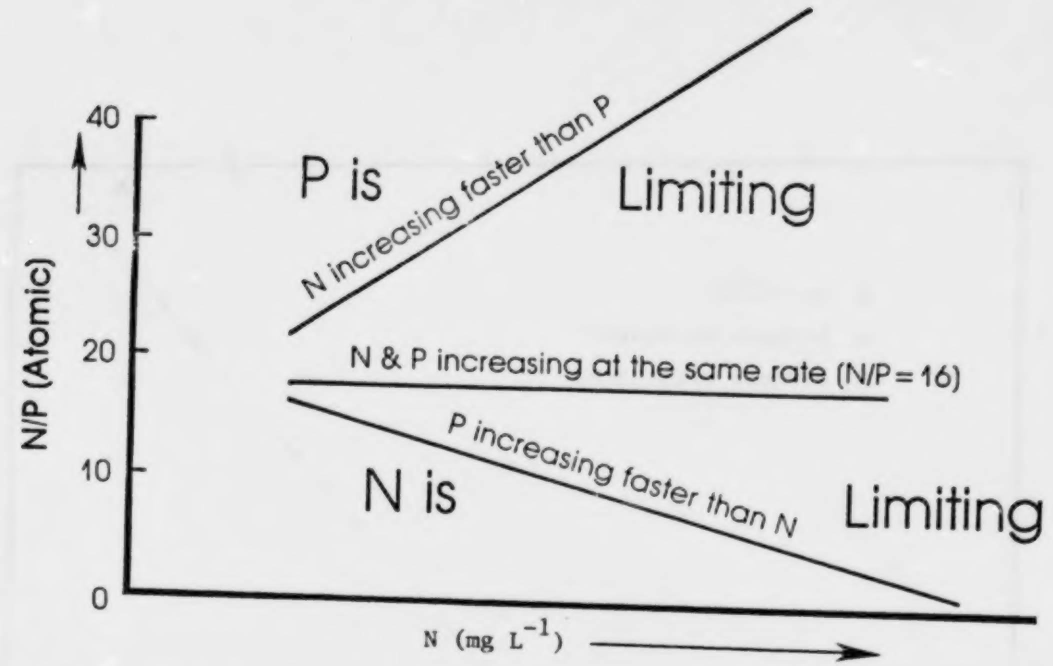

Figure 3a. Conceptual relation between nitrogen concentration and the N/P ratio illustrating the limiting nutrient concept.

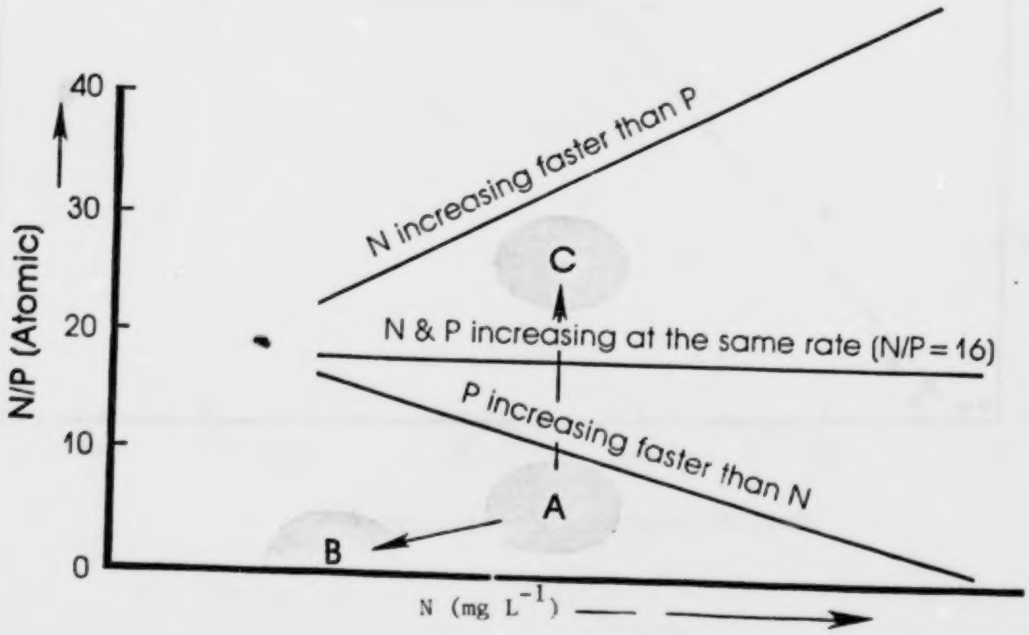

Figure 3b. Management alternatives for modifying water quality.

Plots of this kind have two distinct advantages. First, specific concentrations or concentration ranges of ecological significance can be labeled on the concentration axis, permitting water quality managers to visualize concentration (not load) reductions necessary to make a Patuxent-like segment into a Rappahannock-like segment. Second, the N/P ratio provides a first-order estimate of the nutrient that is potentially limiting phytoplankton production. It is critical to recognize here that the forms in which N and P present may be more important than the total concentrations and that other factors, such as turbidity, may actually be limiting phytoplankton growth. For a detailed discussion of the factors affecting phytoplankton growth and productivity, see Smullen et al. (1982). Phytoplankton, on the average, incorporate N and P in the ratio of 16:1 (by atoms), but that ratio can vary from 10:1 to 20:1 (the shaded area on Figures 3a and b). When the data from specific segments are plotted on such a diagram, the manager can see which nutrient is potentially limiting (above the shaded zone, P is potentially limiting; below the shaded zone N is potentially limiting). If the management objective is reduction of phytoplankton growth by limiting nutrients, and nitrogen is presently limiting production, then one can reduce the ambient N concentration from the field marked A to the concentration field marked B (Figure 3b). Suppose, however, that N cannot be controlled; then one can reduce P, increasing the N/P ratio and forcing P to become limiting. Such a hypothetical scheme is also illustrated in Figure 3b where the initial, and if one supposes, the undesirable envelope of concentration is the field marked A, and the desired (or at least acceptable) field is marked C. To get from the situation in A to the situation in C without changing the concentration of N, one must reduce the concentration of P. A critical caveat must be mentioned; the static nature of N/P ratios fails to give information on the flux of these nutrient forms among the various environmental compartments (i.e., particulate living and non-living and dissolved organic and inorganic materials.)

A real example of the hypothetical scenario outlined above involves the Potomac River. By 1970, the tidal-fresh portion of the river received 11,000 kg day$^{-1}$ of P and 27,000 kg day$^{-1}$ of N from wastewater loading. Advanced wastewater treatment processes, initiated in 1974, were designed to remove P from the wastewater flow. By 1979, the wastewater load of phosphorus to the tidal-fresh Potomac had been reduced to 2,400 kg day$^{-1}$. The summertime concentrations of phosphorus, plotted against the N/P ratio for the tidal-fresh Potomac, are illustrated in Figure 4. The plot shows how the N concentration and N/P ratio changed with institution of the treatment practices. The plot also shows that, despite accumulation of N and P in bottom sediments and their release to the water column, the tidal-fresh Potomac responded rapidly ($<$5 years) and positively to the pollution control strategy. Figure 4 illustrates the decline in TP concentration coincident with, and principally caused by, phosphorus removal from sewage effluents. As phosphorus removal continued, the ratio of N/P doubled.

The data points for all tidal-fresh segments of Chesapeake Bay tributaries, and CB-1, WT-5, and ET-1-4 are illustrated, for summertime (June, July and August), in Figure 5. The York and Rappahannock plot in the lower left portion of the graph form a distinct contrast to the Back River plot. Clearly, estuarine water quality managers can see two strategies for the Patuxent, for example. The Patuxent is potentially

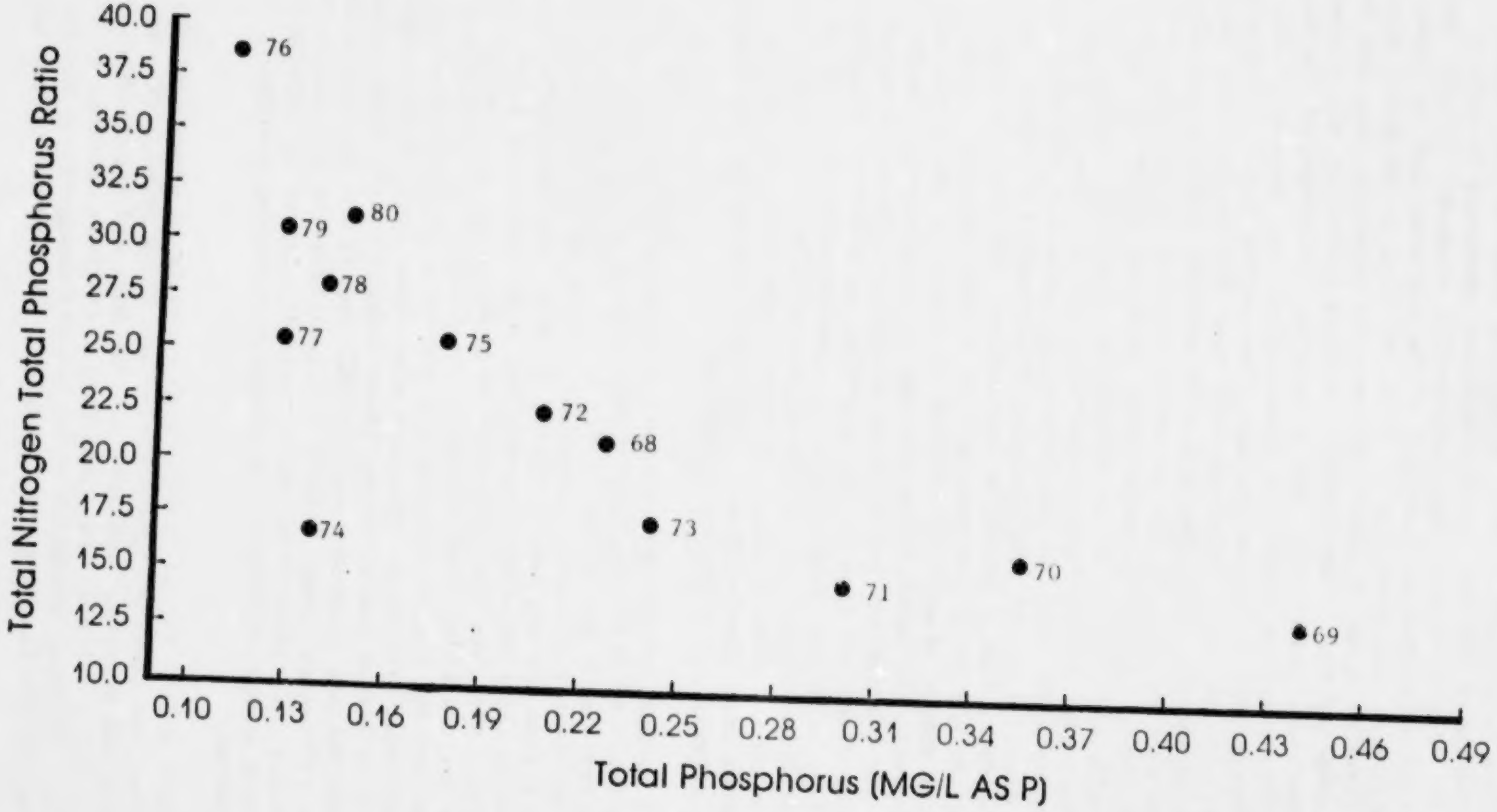

Figure 4. Potomac summertime phosphorus concentration versus N/P ratio.

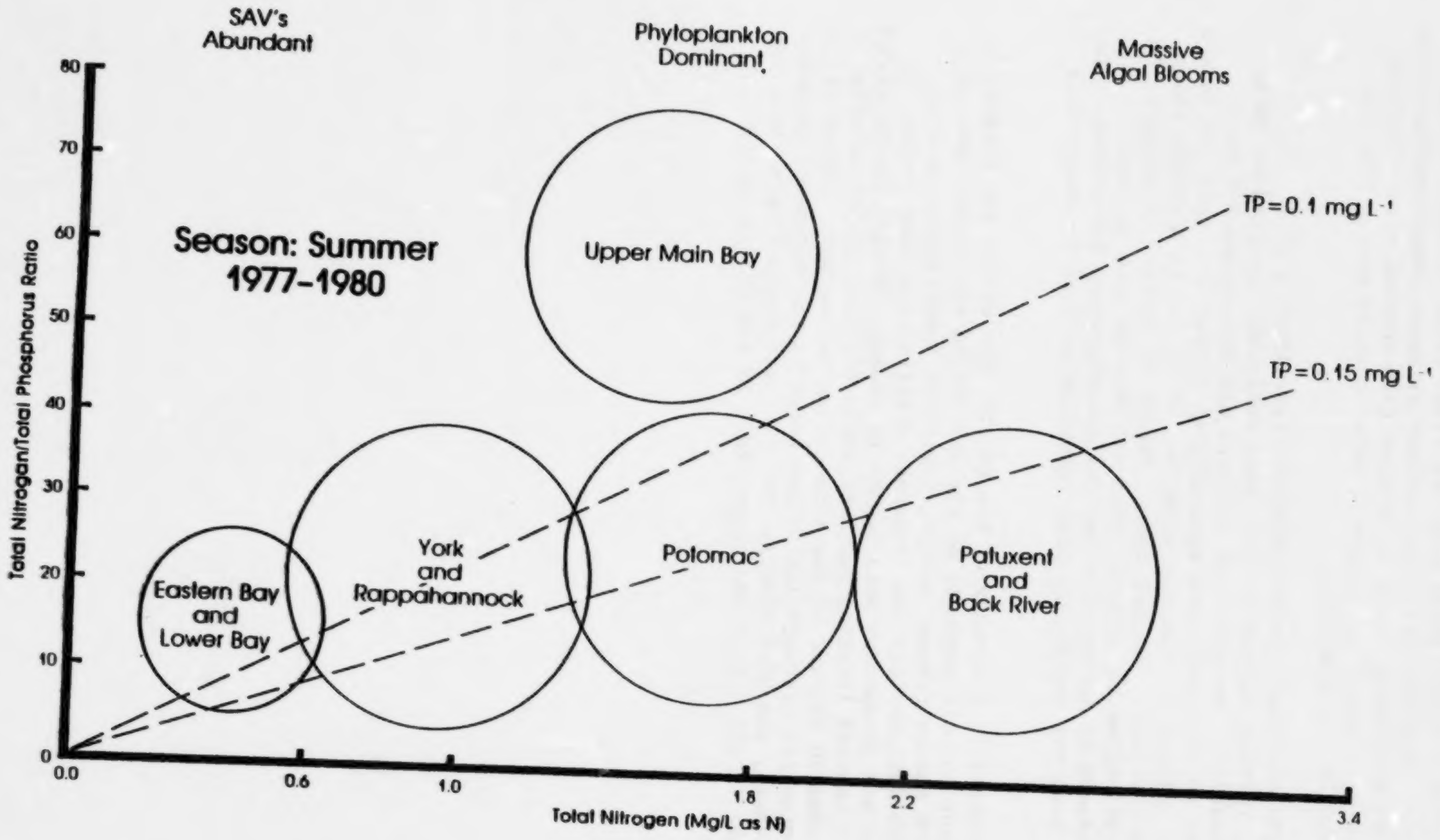

Figure 5. N/P ratios for the tidal-fresh segments of Chesapeake Bay and tributaries.

nitrogen limited during the warm season, and a reduction of nitrogen concentration from about 2.6 mg $L^{-1}$(the center of most of the "data cloud") to 0.6 or 0.7 mg $L^{-1}$ could make the tidal-fresh Patuxent become Rappahannock-like. Alternatively, the ambient nitrogen concentration could be maintained and phosphorus could be reduced from ambient concentrations of 0.4 mg $L^{-1}$ to 0.15 mg $L^{-1}$ to achieve a water quality status like the post-1974 Potomac in the summertime.

The N/P ratio does not consider historic (pre-1968) N or P concentrations, relying instead on the "most desirable" defined as "most desirable at present." Because both the York and Rappahannock Rivers receive nonpoint source loads from agricultural activities, there is reason to believe that neither of them are pristine, or as low in nutrient loads as they were in the past. The N/P ratio, though of utility to managers in predicting concentration reductions, does not provide data on load reductions necessary to achieve the desired concentration reductions. The N/P ratio also does not explicitly link resources to N or P, except in a qualitative way.

Table 1 illustrates a summary of the TN, TP, N/P ratio, and potential limiting nutrient for all segments of the Bay during the decade from 1970 to 1980 for each season (except winter, for which insufficient data are available). Table 2 provides the frequency distribution data on the 734 paired nitrogen and phosphorus data points by season. Phosphorus is always the principal potential limiting nutrient while nitrogen is potentially limiting less than 10 percent of the time during any season. Almost all of the cases of potential nitrogen limitation occur in the Patuxent, Potomac, James, Rappahannock, and York Rivers. In the first three rivers, both TN and TP are high; in the latter two cases, both TN and TP are in low concentrations.

TABLE 1. MAXIMUM AND MINIMUM SEASONAL NITROGEN (TN) AND PHOSPHORUS (TP) CONCENTRATIONS IN CHESAPEAKE BAY SEGMENTS DURING THE PERIOD 1970-1980. CONCENTRATIONS IN mg $L^{-1}$, N/P BY ATOMS

| | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Segment | | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] |
| CB1 | max. | .20 | 2.17 | 66 | P(10) | .14 | 1.89 | 59 | P(9) | .23 | 1.61 | 80 | P(8) |
| | min. | .05 | 1.16 | 25 | | .04 | .87 | 17 | ?(1) | .04 | 1.02 | 13 | ?(1) |
| CB2 | max. | .22 | 2.08 | 84 | P(10) | .16 | 1.34 | 59 | P(10) | .19 | 2.00 | 92 | P(8) |
| | min. | .04 | 1.12 | 22 | | .03 | .74 | 19 | ?(1) | .04 | .99 | 11 | ?(1) |
| CB3 | max. | .36 | 2.16 | 69 | P(10) | .18 | 1.47 | 53 | P(8) | .10 | 1.82 | 77 | P(1) |
| | min. | .05 | 1.06 | 12 | ?(1) | .04 | .45 | 12 | ?(3) | .02 | .72 | 23 | |
| CB4 | max. | .15 | 1.49 | 77 | P(10) | .16 | .97 | 44 | P(7) | .17 | .93 | 34 | P(9) |
| | min. | .03 | .87 | 22 | | .04 | .38 | 12 | ?(3) | .04 | .44 | 6 | N(1) |
| CB5 | max. | .15 | 1.38 | 278 | P(8) | .15 | 1.03 | 73 | P(6) | .10 | .81 | 37 | P(6) |
| | min. | .01 | .70 | 21 | | .02 | .34 | 12 | ?(2) | .03 | .45 | 15 | ?(2) |
| CB6,7,8 | | ----------------------------Insufficient data---------------------------------------- | | | | | | | | | | | |
| Eastern Bay<br>EE1 | max. | .12 | .81 | 32 | P(2) | .08 | .66 | 27 | P(2) | .10 | .74 | 24 | P( ) |
| | min. | .05 | .53 | 14 | ?(2) | .05 | .36 | 14 | ?(3) | .05 | .53 | 15 | ?( ) |
| Choptank<br>EE2 | max. | .19 | .65 | 22 | P(1)<br>?(1) | .09 | .88 | 34 | P(3) | .06 | .43 | 22 | P(1) |
| | min. | .04 | .35 | 7 | N(1) | .04 | .58 | 17 | ?(1) | .04 | .38 | 14 | ?(1) |

(continued)

TABLE 1. (Continued)

| | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Segment | | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] |
| Pocomoke Sound<br>EE3 | max. | .06 | .89 | 34 | P(4) | .10 | 1.06 | 38 | P(5) | .08 | 1.12 | 42 | P(3)<br>?(2) |
| | min. | .05 | .75 | 29 | | .04 | .64 | 20 | | .05 | .47 | 15 | |
| NE River<br>ET1 | max. | .11 | 1.42 | 63 | P(7) | .17 | 1.43 | 44 | P(7)<br>?(1) | .26 | 1.21 | 70 | P(5)<br>?(2) |
| | min. | .05 | 1.13 | 28 | | .04 | .45 | 15 | | .03 | .41 | 11 | |
| Elk River<br>ET2 | max. | .60 | 2.62 | 61 | P(7)<br>?(1) | .16 | 1.69 | 38 | P(8) | .11 | 2.72 | 97 | P(7) |
| | min. | .06 | 1.43 | 14 | | .06 | .95 | 21 | | .05 | .94 | 41 | |
| Sassafras<br>ET3 | max. | 1.4 | 1.98 | 81 | P(7)<br>N(1) | .11 | 1.49 | 38 | P(5)<br>?(2) | .16 | 1.31 | 34 | P(5)<br>?(1) |
| | min. | .04 | .87 | 3 | | .06 | .58 | 17 | | .05 | .55 | 19 | |
| Chester<br>ET4 | max. | .64 | 2.67 | 38 | P(3)<br>?(1)<br>N(1) | .20 | 1.84 | 47 | P(4)<br>?(1)<br>N(1) | .30 | 1.50 | 29 | P(2)<br>?(4)<br>N(1) |
| | min. | .07 | 1.25 | 9 | | .05 | .54 | 10 | | .06 | .50 | 8 | |
| ET5 | max. | .41 | 2.32 | 59 | P(6)<br>?(1) | .16 | 2.92 | 78 | P(7)<br>?(1) | .41 | 2.05 | 110 | P(6)<br>N(1) |
| | min. | .06 | 1.30 | 13 | | .07 | .79 | 17 | | .04 | .85 | 8 | |
| ET6 | max. | .70 | 2.19 | 91 | P(6)<br>N(1) | .14 | 1.61 | 46 | P(5)<br>?(1) | .14 | 2.01 | 59 | P(5) |
| | min. | .04 | 1.53 | 7 | | .04 | .43 | 17 | | .04 | .98 | 21 | |
| ET7 | max. | .21 | 3.07 | 99 | P(6) | .40 | 2.64 | 44 | P(4)<br>?(2) | .38 | 1.81 | 51 | P(4)<br>N(1) |
| | min. | .07 | 1.91 | 29 | | .08 | .68 | 15 | | .07 | 1.10 | 9 | |

(Continued)

TABLE 1. (Continued)

| Segment | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TP | TN | N/P | Limit$^1$ | TP | TN | N/P | Limit$^1$ | TP | TN | N/P | Limit$^1$ |
| ET8 | max. | .05 | 1.10 | 50 | P(2) | .08 | .67 | 35 | P(2) | No data | | | |
| | min. | .04 | .44 | 25 | | .03 | .46 | 18 | ?(1) | | | | |
| ET9 | max. | No data | | | | .05 | .73 | 33 | P(2) | No data | | | |
| | min. | | | | | .03 | .34 | 22 | | | | | |
| ET10 | max. | .21 | 2.00 | 53 | P(5) | .54 | 1.77 | 36 | P(3)<br>?(3) | .15 | 1.57 | 44 | P(2) |
| | min. | .08 | .89 | 20 | | .08 | .44 | 7 | N(1) | .05 | .66 | 14 | ?(3) |
| WT1 | max. | .08 | 2.34 | 107 | P(2) | .22 | 2.98 | 71 | P(3) | .05 | 3.32 | 190 | P(3) |
| | min. | .05 | 1.58 | 42 | | .05 | 1.20 | 31 | | .04 | 2.03 | 86 | |
| WT2 | max. | .07 | 1.77 | 90 | P(4) | .18 | 2.20 | 125 | P(7) | .07 | 1.91 | 82 | P(6) |
| | min. | .03 | 1.15 | 50 | | .04 | 1.01 | 26 | | .04 | .89 | 29 | |
| WT3 | max. | .06 | 1.47 | 72 | P(4) | .07 | .80 | 30 | P(2) | .07 | .82 | 47 | P(1) |
| | min. | .03 | .47 | 36 | | .06 | .28 | 11 | ?(3) | .04 | .35 | 15 | ?(3) |
| WT4 | max. | .45 | 6.32 | 220 | P(4) | .31 | 5.32 | 58 | P(4) | .39 | 7.28 | 66 | P(3) |
| | min. | .04 | 3.89 | 25 | | .21 | 2.25 | 16 | ?(1) | .15 | 1.76 | 12 | ?(2) |
| WT5 | max. | .21 | 2.49 | 83 | P(9) | .21 | 2.24 | 68 | P(7) | .15 | 1.93 | 77 | P(7) |
| | min. | .06 | 1.50 | 27 | | .07 | 1.97 | 18 | ?(2) | .06 | .67 | 20 | ?(1) |
| WT6 | max. | .10 | 1.31 | 150 | P(4) | .12 | 1.12 | 35 | P(2) | .12 | 1.35 | 42 | P(3) |
| | min. | .02 | .87 | 20 | | .03 | .45 | 12 | ?(2) | .04 | .35 | 13 | ?(2) |

(Continued)

TABLE 1. (Continued)

| | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Segment | | TP | TN | N/P | Limit$^1$ | TP | TN | N/P | Limit$^1$ | TP | TN | N/P | Limit$^1$ |
| WT7 | max. | .12 | 1.17 | 62 | P(5) | .10 | 1.46 | 114 | P(5) | .13 | 2.14 | 75 | P(2)<br>?(3) |
| | min. | .03 | .26 | 12 | ?(1) | .02 | .45 | 15 | ?(1) | .06 | .46 | 9 | N(2) |
| WT8 | max. | .08 | 1.62 | 62 | P(5) | .22 | 1.40 | 50 | P(2)<br>?(4) | .16 | 1.16 | 22 | P(2)<br>?(2) |
| | min. | .04 | .75 | 29 | | .06 | .34 | 6 | N(2) | .08 | .45 | 9 | N(2) |
| TF1 | max. | 1.98 | 2.56 | 23 | P(1)<br>?(6) | 2.02 | 4.19 | 29 | P(1)<br>?(6) | 1.22 | 4.14 | 16 | ?(6) |
| | min. | .16 | 1.49 | 2 | N(1) | .22 | 1.37 | 1 | N(1) | .41 | 1.71 | 3 | N(2) |
| TF2 | max. | .26 | 2.07 | 40 | P(7) | .35 | 2.48 | 39 | P(7) | .46 | 2.87 | 45 | P(8) |
| | min. | .08 | 1.42 | 17 | ?(4) | .11 | 1.02 | 15 | ?(4) | .10 | 1.17 | 14 | ?(2) |
| TF3 | max. | | No data | | | | No data | | | .12 | 1.11 | 22 | P(1) |
| | min. | | | | | | | | | .09 | .68 | 15 | ?(3) |
| TF4 | max. | .15 | .82 | 38 | P(1)<br>?(1) | .22 | 1.01 | 28 | P(1)<br>?(4) | .13 | .76 | 17 | ?(6) |
| | min. | .05 | .24 | 5 | N(3) | .07 | .57 | 8 | N(3) | .07 | .44 | 11 | |
| TF5 | max. | .18 | 1.62 | 37 | P(3)<br>?(4) | .20 | 1.96 | 31 | P(4)<br>?(5) | .37 | 2.30 | 39 | P(4)<br>?(5) |
| | min. | .10 | .74 | 8 | N(2) | .10 | .84 | 10 | | .10 | .51 | 8 | N(1) |
| RET1 | max. | .14 | 1.36 | 21 | P(1) | .18 | .99 | 15 | ?(1) | .16 | .77 | 12 | ?(1) |
| | min. | .13 | .68 | 11 | ?(1) | .11 | .25 | 5 | N(2) | .15 | .51 | 7 | N(1) |

(Continued)

TABLE 1. (Continued)

| | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Segment | | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] |
| RET2 | max. | .25 | 2.20 | 42 | P(9) | .23 | 2.52 | 44 | P(4)<br>?(6)<br>N(1) | .24 | 1.72 | 44 | P(5) |
| | min. | .09 | 1.02 | 13 | ?(2) | .08 | .63 | 9 | | .09 | .65 | 12 | ?(5) |
| RET3 | max. | .19 | 1.13 | 15 | ?(4) | .16 | 1.45 | 33 | P(1) | .13 | .80 | 16 | ?(4) |
| | min. | .11 | .73 | 13 | | .10 | .54 | 11 | ?(3) | .08 | .53 | 14 | |
| RET4 | max. | .16 | .67 | 19 | ?(2) | .13 | .57 | 13 | ?(2) | .15 | .76 | 18 | ?(4) |
| | min. | .07 | .29 | 7 | N(4) | .10 | .53 | 9 | N(1) | .09 | .36 | 9 | N(1) |
| RET5 | max. | .11 | 1.67 | 51 | P(3) | .15 | 1.20 | 34 | P(4) | .20 | 1.30 | 30 | P(2)<br>?(3)<br>N(2) |
| | min. | .07 | .72 | 14 | ?(1) | .08 | .87 | 15 | ?(2) | .10 | .40 | 9 | |
| LE1 | max. | .18 | 1.36 | 25 | P(1)<br>?(2)<br>N(1) | .27 | .97 | 22 | P(1)<br>?(1)<br>N(3) | .13 | .59 | 14 | ?(1) |
| | min. | .07 | .43 | 9 | | .06 | .24 | 3 | | .09 | .43 | 7 | N(1) |
| LE2 | max. | .10 | 1.18 | 45 | P(5) | .11 | 1.30 | 47 | P(3)<br>?(5)<br>N(1) | .11 | .86 | 28 | P(2)<br>?(2)<br>N(1) |
| | min. | .05 | .49 | 18 | ?(2) | .06 | .29 | 7 | | .05 | .32 | 9 | |
| LE3 | max. | .13 | 1.42 | 65 | P(2) | No data | | | | .30 | .87 | 32 | P(2)<br>?(2)<br>N(1) |
| | min. | .05 | .46 | 11 | ?(2) | | | | | .04 | .48 | 6 | |

(Continued)

TABLE 1. (Continued)

| | | Spring(March,April,May) | | | | Summer(June,July,Aug.) | | | | Autumn(Sept.,Oct.,Nov.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Segment | | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] | TP | TN | N/P | Limit[1] |
| LE4 | max. | | No data | | | .09 | .51 | 13 | ?(2) | .09 | .77 | 24 | P(1)<br>?(2)<br>N(1) |
| | min. | | | | | .06 | .36 | 12 | | .07 | .27 | 8 | |
| LE5 | max. | .12 | 1.09 | 24 | P(3) | .11 | 1.06 | 24 | P(3)<br>?(3)<br>N(1) | .15 | 1.17 | 27 | P(4)<br>?(3)<br>N(1) |
| | min. | .10 | .61 | 11 | ?(3) | .08 | .17 | 4 | | .08 | .39 | 9 | |

---

[1] "Limit" determines potential phytoplankton limiting nutrient defined as follows:

(a) If N/P (atoms) $\leq$ 10, then N is limiting [symbol is "N", (#) is frequency].
(b) If 10 $<$ N/P $\leq$ 20, then limiting nutrient is indeterminate [symbol is ?, (#) is frequency].
(c) If N/P $>$ 20, then P is limiting [symbol is "P", (#) is frequency]. See discussion of assumptions.

TABLE 2. FREQUENCY OF OCCURRENCE OF NITROGEN OR PHOSPHORUS AS A POTENTIALLY LIMITING NUTRIENT FOR PHYTOPLANKTON. ALL DATA IN CBP DATA BASE FOR 1970 TO 1980

| Season Nutrient | Spring (Mar., April, May) | Summer (June, July, Aug.) | Autumn (Sept., Oct., Nov.) | TOTALS |
|---|---|---|---|---|
| TN[1] | 15 ( 6%) | 17 ( 7%) | 20 ( 8%) | 52 ( 7%) |
| ?[2] | 42 (18%) | 83 (32%) | 81 (34%) | 206 (28%) |
| TP[3] | 179 (76%) | 158 (61%) | 139 (58%) | 476 (65%) |
| TOTALS | 236 | 258 | 240 | 734 |

[1] Nitrogen is defined as potentially limiting when N/P (by atoms) is less than or equal to 10.

[2] The potentially limiting nutrient is indeterminate when N/P (by atoms) falls in the range of less than or equal to 20 and greater than 10.

[3] Phosphorus is defined as potentially limiting when N/P (by atoms) is greater than 20.

## SECTION 3

# INSIGHTS GAINED FROM THE LITERATURE

## NUTRIENTS AND PHYTOPLANKTONIC STANDING CROPS

Ketchum (1969) analyzed a large body of data and concluded that phosphorus enrichment in estuaries should be considered at a danger level when concentrations approach 2.55 ug of $L^{-1}$ (0.079 mg $L^{-1}$) in winter and 1.7 ug of $L^{-1}$ (0.053 mg $L^{-1}$) in summer. Carpenter et al. (1969) found that when Potomac River concentrations of nitrate reached 100 to 150 ug atoms per liter (1.4 to 2.1 mg $L^{-1}$) and phosphorus levels reached 5 ug atoms per liter (0.155 mg $L^{-1}$) (high flow) or when nitrate reached 50 to 70 ug atoms per liter (0.90 to 0.98 mg $L^{-1}$) and phosphate reached 3 to 5 ug atoms per liter (0.093 to 0.155 mg $L^{-1}$) (low flow), high concentrations of chlorophyll were produced by Microcytis aeruginosa which floats to form highly visual discolorations and collects on the shoreline in unattractive mats. The conditions were also accompanied by a more pronounced decrease in dissolved oxygen ($\leq$1 ml $L^{-1}$) at depth in the Potomac River than occurred at depth in the upper Chesapeake.

Jaworski et al. (1972), reviewing historical data for the upper Potomac estuary, indicated that if the concentrations of inorganic phosphorus and inorganic nitrogen were at or above 0.1 and 0.5 mg $L^{-1}$, respectively, algal blooms of approximately 50 ug $L^{-1}$ or more were considered indicative of excessive algal growths. Studies of the James River estuary, a sister estuary to the Potomac, by Brehmer (1967), indicate that nitrogen appears to be the rate-limiting nutrient.

Based upon several analyses, including bioassays and algal modeling, Jaworski et al. (1972) developed the following criteria for reversing eutrophication in the freshwater portion of the tidal Potomac River:

| | |
|---|---|
| Inorganic nitrogen | 0.30 to 0.5 mg $L^{-1}$ |
| Total phosphorus | 0.03 to 0.1 mg $L^{-1}$ |

These authors indicate that:

> The lower values in these ranges are to be applied to the freshwater portion of the middle reach and to the embayment portions of the estuary in which the environmental conditions are more favorable for algal growth. The upper ranges of the criteria are more applicable to the upper reach of the Potomac estuary, which has a light-limited eutrophic zone of usually less than 0.6 m in depth.
>
> Studies of the mesohaline portion of the Potomac estuary showed a relatively sharp transition from freshwater to a typical mesohaline environment. At the upper end of the 35 km transition zone at Maryland Point there are primarily freshwater phytoplankton and zooplankton populations. Above Maryland Point, the salinities are less than two percent. Predominantly marine forms dominate the lower end of the transition zone at the Route 301 Bridge, with salinities in summer approximating 12 ppt. Based on five years of field studies, it appears that the growth of massive blue-green algal mats are apparently restricted to the freshwater portions. In the mesohaline environment, dinoflagellates were often encountered in "red tide" proportions.

These observations lead to two points of emphasis in estuarine water quality management: 1) fairly discrete biotic provinces may be identified within a given reach of the estuary, responding differently to a given stress; and 2) there is insufficient evidence to date to generalize on nutrient parameters and hypertrophic conditions in all portions of a given estuary. Therefore, at the present time no specific nutrient criteria have been established for the mesohaline portion of the Potomac estuary.

Figure 6 shows important historical changes in nutrient enrichment trends and ecological changes for the upper tidal Potomac from 1913 to 1970 (Jaworski et al. 1972). The nutrient concentrations in the upper estuary under summer conditions before 1920 were estimated to be from 0.04 to 0.07 mg $L^{-1}$ of phosphorus with inorganic nitrogen ranging from 0.15 to 0.30 mg $L^{-1}$. With a reversion to these concentrations, not only should there be a significant reduction in the blue-green algal population but there should also be a general reversal in the ecological succession of the community.

The Patuxent River estuary showed large increases in the levels of nitrate-nitrogen and dissolved inorganic phosphate-phosphorus between 1963 to 1964 and 1968 to 1970 (Flemer et al. 1970, Herman et al. 1967). Table 3 compares the available data on nitrogen, phosphorus, and chlorophyll a for these two study periods. Salinities were approximately similar between years at stations used in the comparison. Thus, physical dispersion is assumed to be roughly similar for each study. Nitrate-nitrogen increased significantly over the six-year period at the upper and lower river stations, respectively. The greatest relative increases occurred in the higher saline waters. A smaller increase was noted in phosphate between the two periods. Chlorophyll a levels approximated each other over the two study periods at Lower Marlboro but a significant increase occurred at Queentree Landing from 1963 to 1964 and 1968 to 1970. If it is assumed that the 1968 to 1970 chlorophyll a normalized to uncorrected values would increase by 30 percent, than the increase in chlorophyll a is more striking.

The data on the Patuxent River estuary are intended to show that the system responded rapidly to nutrient enrichment. Later studies (Heinle et al. 1980) have shown even higher levels of nutrients and chlorophyll a. The highest nitrate levels occurred during the winter and approximately a four-fold increase between 1963 to 1964 and 1968 to 1970 in nitrate at comparable salinities (a measure of dilution) was indicative of a six- to seven-fold increase in chlorophyll a (uncorrected values in 1968 to 1970 estimated to be 30 percent higher than corrected reported values).

During the summer of 1970 in the Patuxent, when the total dissolved nitrogen ($NH_3$, $NO_2$, $NO_3$, and dissolved organic nitrogen) averaged 0.71 mg $L^{-1}$ (N = 4) at Lower Marlboro (salinity approximated 1.4 ppt), the estimated uncorrected chlorophyll a averaged 43 ug $L^{-1}$ (N = 4). At the Queentree Landing station, the salinity for the summer of 1970 averaged 10 ppt and the total dissolved nitrogen and chlorophyll a averaged (N = 4) 0.26 mg $L^{-1}$ and 52 ug $L^{-1}$, respectively. These data show that different salinity regimes in the Patuxent correlate differently with the concentration of nitrogen. The higher saline reach of the Patuxent exhibited a higher level of chlorophyll a per unit concentration of nitrogen than the low saline (upper) reach.

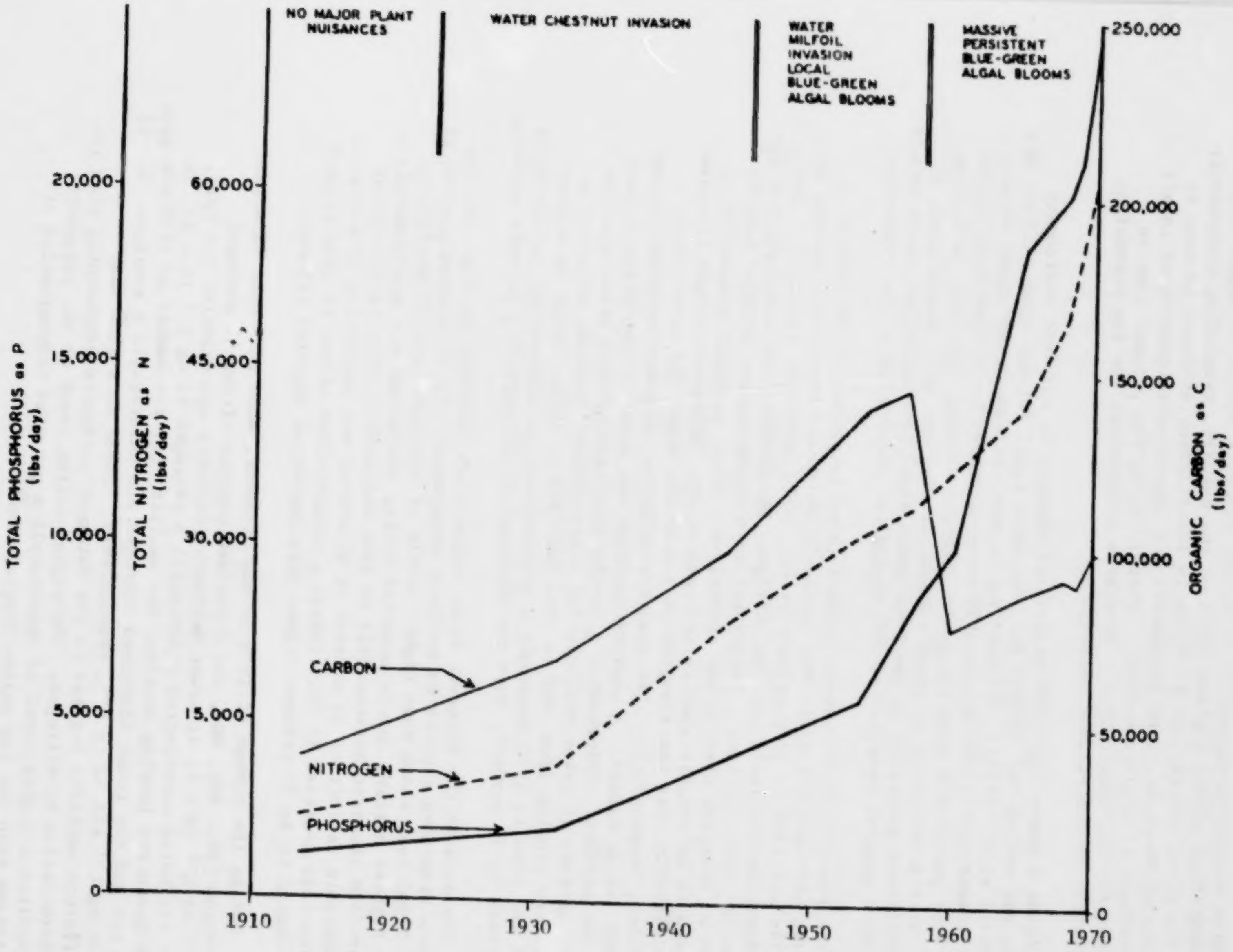

Figure 6. Wastewater nutrient enrichment trends and ecological effects on the upper Potomac tidal river system 1913 to 1970 (Jaworski et al. 1971).

TABLE 3. ANNUAL RANGE IN CONCENTRATION OF SEVERAL PHOSPHORUS AND NITROGEN FRACTIONS FROM SURFACE WATERS OF SELECTED AREAS IN THE PATUXENT RIVER FOR THE PERIODS FROM 1963 TO 1964 AND 1963 TO 1968. ALL VALUES ARE EXPRESSED AS mg $L^{-1}$ (TABLE ADAPTED FROM FLEMER ET AL. 1970)

|  | Salinity ppt | NO3-N | NH3-N | DIP | TP | chlorophyll *a*[1] | References |
|---|---|---|---|---|---|---|---|
| Patuxent River |  |  |  |  |  |  |  |
| Lower Marlboro | 0.1- 5.5 | 0.003-0.71 | 0.011-0.62 | 0.003-0.11 | 0.12-0.49 | 2.8-43.7 | Flemer et al. 1970 |
| Queentree | 8.4-15.6 | 0.0-0.17 | 0.02-0.25 | 0.003-0.11 | 0.02-0.38 | 3.0-59.8 |  |
| Patuxent River |  |  |  |  |  |  |  |
| Lower Marlboro | 0.1-7.6 | trace-0.19 |  | 0.006-0.03 |  | 3.0-45.0 | Mihursky, et al. 1967 |
| Queentree | 7.8-16.5 | trace-0.004 |  | 0.003-0.04 |  | 1.0-10.0 |  |

[1] Chlorophyll *a* values corrected for degradation products in 1968 to 1970 but no correction applied to 1963 to 1964 data.

The total dissolved inorganic nitrogen (DIN) in the Patuxent during the summer of 1970 averaged 0.36 mg $L^{-1}$ at Lower Marlboro and the uncorrected chlorophyll a level averaged about 43 mg $L^{-1}$. At Queentree for the same period, the $\overline{\text{DIN}}$ averaged 0.05 mg $L^{-1}$ and chlorophyll a averaged 52 ug $L^{-1}$.

The Patuxent River data and other studies discussed suggest that when the total nitrogen approaches 1.0 mg $L^{-1}$ in tidal-fresh to brackish water, then the chlorophyll a levels are likely to reach 50 ug $L^{-1}$, a level of concern or, at least, a "danger" signal concerning aesthetics and probable low levels of dissolved oxygen. The latter point requires more information for a calibration to various environmental conditions. During the summer, much of the nitrogen is incorporated into chlorophyll a related organic material. The "danger" level of phosphate-phosphorus in tidal-freshwater is probably near 0.10 to 0.15 mg $L^{-1}$. The "level of danger" of this nutrient form at higher salinities is less certain.

## SECTION 4

# SUBMERGED AQUATIC VEGETATION AND NUTRIENTS

Submerged aquatic vegetation (SAV) has declined markedly in Chesapeake Bay during the past 10 to 15 years (Flemer et al. 1983; Orth and Moore 1982). Factors related to the decline are discussed in the CBP characterization report, Chapter 3, and in Kemp et al. (1982). Submerged grasses in Chesapeake Bay generally are limited in their growth by the availability of light (Wetzel et al. 1982). Thus, factors that affect the amount of light that can penetrate the water column will affect the well-being of submerged grasses. Two such factors are nutrients and turbidity.

## NUTRIENTS

High nutrient concentrations can hinder SAV growth through the production of phytoplankton biomass. In addition, nutrients may encourage the growth of epiphytes on grass leaf surfaces, decreasing light availability (Twilley et al. 1982). Studies of experimental microcosms (Twilley et al. 1982) indicate that nitrogen loads resulting in concentrations of 0.7 mg $L^{-1}$ initiate excessive epiphyte biomass, phytoplankton growth, and stress of SAV. Phosphorus loads resulting in concentrations of 0.15 mg $L^{-1}$ are also stressful. Effects of nitrogen and phosphorus loads on SAV biomass were shown in Figure 2. Boynton[1] suggests that nutrient concentrations may be deceptive in assessing effects on SAV because epiphytes take up so much of the nutrients. He feels that nutrient loads should be considered as well. From Figure 2 it can be seen that nitrogen loads of 30 to 60 u mol per week and phosphorus loads of 2.6 to 6 u mol per week are sufficient to reduce SAV biomass.

These results are further substantiated by a significant correlation between the percentage of sites vegetated and the total nitrogen concentration in Maryland (Figure 1). The percentage of sites vegetated declined abruptly when total nitrogen concentrations exceeded 0.8 mg $L^{-1}$. There was no correlation between phosphorus and SAV, probably because phosphorus concentrations in most segments are below critical levels. Rank correlation of expected habitat and total nitrogen for the entire Bay (Flemer et al. 1983) was also significant. The value of 0.60 mg $L^{-1}$ total nitrogen is suggested by these results as the highest concentration that could be expected to support abundant SAV.

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[1] Personal Communication: "Effect of Nutrient Concentrations on SAV," W. Boynton, University of Maryland, CBL, 1983.

## SECTION 5

# NUTRIENTS, DISSOLVED OXYGEN, AND FISHERIES

## NUTRIENTS

Excess nutrients may result in excessive production of organic material. This material must ultimately be oxidized, possibly resulting in depletion of oxygen. Oxygen depletion is most serious in the summer because increased temperatures cause increased oxygen utilization and decreased oxygen solubility. Bottom waters are most sensitive to oxygen depletion because the pycnocline prevents rapid reaeration. The extent of salinity stratification, a function primarily of freshwater flow, will determine the extent to which bottom waters can be reaerated from surface waters.

Deeper waters, like the main channel of Chesapeake Bay, are most sensitive to oxygen loss. This area has historically been subject to low dissolved oxygen levels in summer, but the spatial and temporal extent of low dissolved oxygen have increased in concert with increased nutrients Flemer et al. 1983). In addition, anoxic waters (zero dissolved oxygen) now occur regularly in summer, a rare phenomenon in the 1950's and early 1960's (Figure 7). Changes in dissolved oxygen profiles can be expected to affect Bay resources, particularly benthic species such as oysters.

## DISSOLVED OXYGEN

Many factors other than nutrients affect dissolved oxygen profiles. To understand these factors, the main channel of Chesapeake Bay was studied in detail, as described in Flemer et al. 1983. This area has a good historical record back to 1949 through data collected by the Chesapeake Bay Institute of The Johns Hopkins University.

Data from two stations in CB-4 for 11 years between 1949 and 1980 were analyzed. Results indicated that, in July, the difference between dissolved oxygen concentrations above the pycnocline and those below the pycnocline ($\Delta$ DO) were related to the extent of salinity stratification ($\Delta$S) (Figure 8). Thus, the greater the stratification is, the greater will be the difference between dissolved oxygen concentrations above and below the pycnocline. This relationship is independent of dissolved oxygen concentrations, and depends only slightly on differences in oxygen solubility (Figure 8). It can be concluded that stratification and the concentration of DO above the pycnocline are the major factors controlling DO concentrations below the pycnocline in this area of CB-4.

With this relationship it is possible to calculate the concentration of dissolved oxygen above the pycnocline that is needed to sustain a desired bottom concentration. For example, if S is 0.50, then the DO level will be -0.50 (Figure 9). If the pycnocline extends to 8 meters, then

$$\frac{\text{DO upper} - \text{DO lower}}{8} = -0.49$$

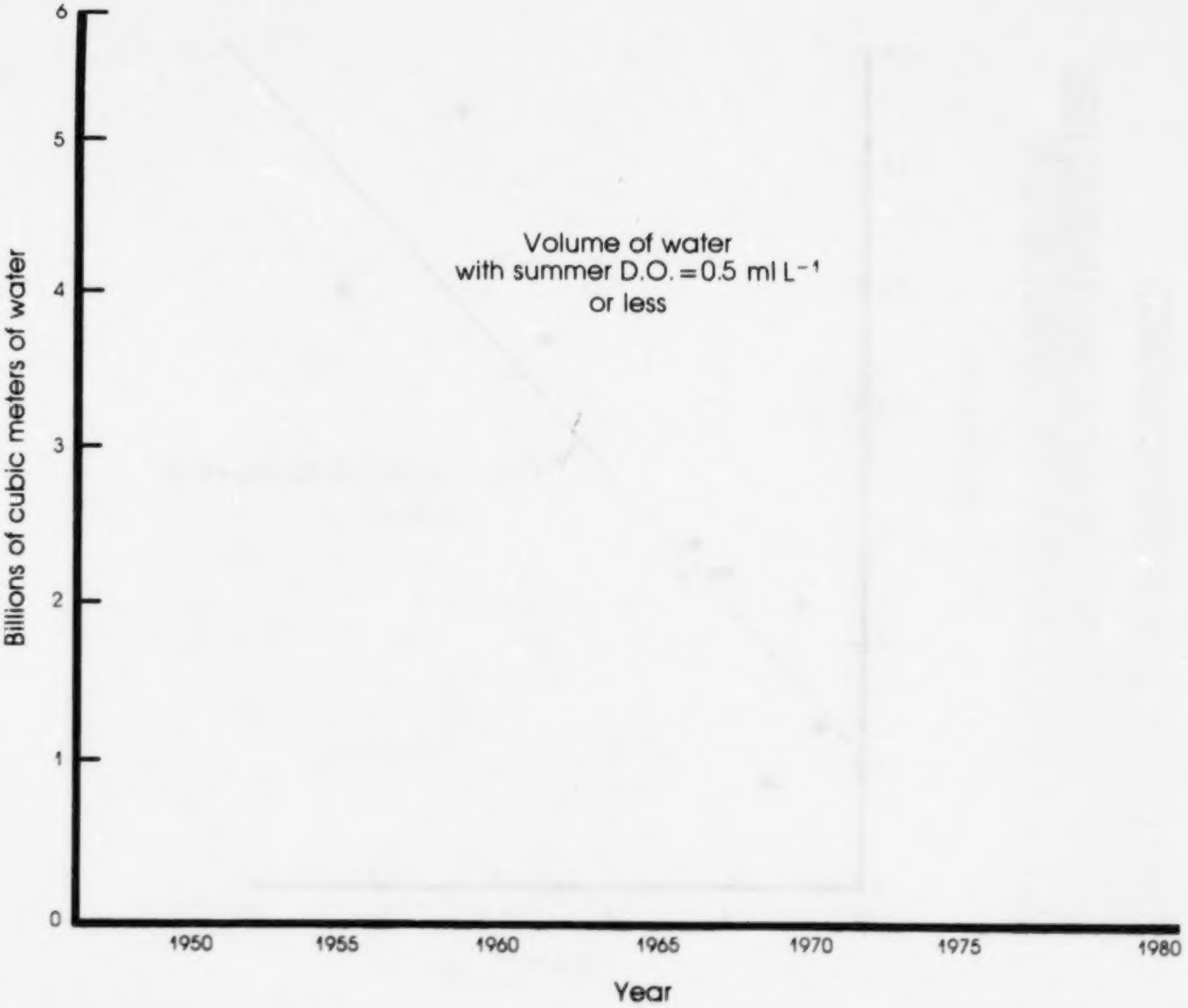

Figure 7. Volume of water in Chesapeake Bay with low levels of dissolved oxygen, 1950 to 1980.

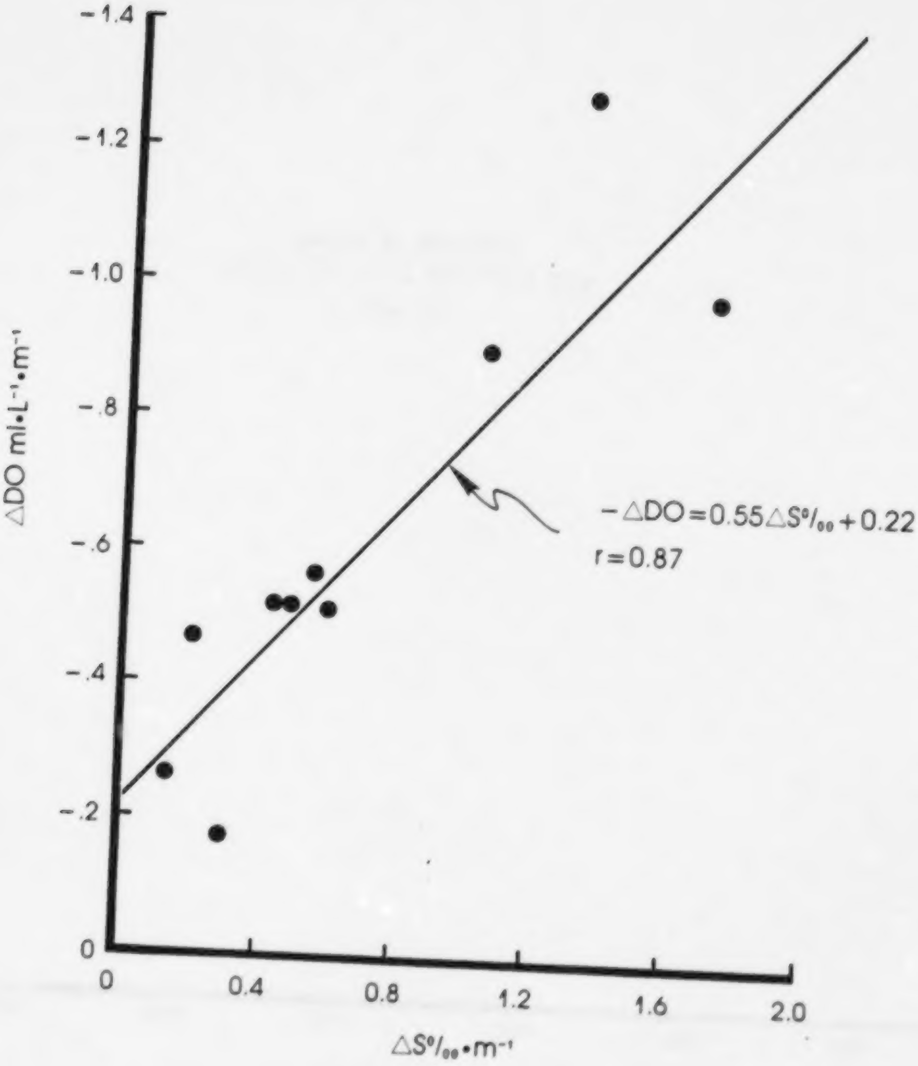

Figure 8. Oxygen decrease per unit salinity increase at stations 848E and 845F in July 1949 to 1980.

If the desired concentration below the pycnocline is 0.5 ml $L^{-1}$, then the concentration above the pycnocline must be at least 4.5 ml $L^{-1}$.

## RELATIONSHIP TO NUTRIENTS

Officer et al. (1983) have developed a model of the mid-Chesapeake anoxia phenomena showing that a nominal benthic respiration rate of 2.0 $O_2$ $m^{-2}$ $day^{-1}$ is adequate to drive the dissolved oxygen level to zero below the pycnocline. They concluded that the principal factor causing the anoxic conditions appears to be historic increases in yearly phytoplankton production which, in turn, are related to the increase in anthropogenic nutrient inputs to be upper Bay. Significant changes in nutrient loads to the Bay are not seen; however, increases in nutrient concentrations in the water column and increases in the volume of anoxic water are apparent.

The process of nutrient recycling tends to amplify changes in the nutrient load from external sources, that is, nutrients, once entering the Bay, may be used several times before they leave the Bay. The CBP has estimated the range of recycling that must occur in the Bay to support observed levels of primary production. For the reach of the main Bay from CB-1 to CB-5, the nutrient recycling rate varies with season (illustrated in Table 4). Assuming that N and P are remineralized on the order of 3 to 5 times during the summer, we can now estimate the nutrient load reduction necessary to achieve specified dissolved oxygen concentrations in deep Bay waters.

The volume of low DO waters is $5 \times 10^9 m^3$. To raise that volume from 0 to 2.8 mg $L^{-1}$ (2.0 ml $L^{-1}$), $(2.8g)(5 \times 10^9 m^3)$ is needed to equal $14 \times 10^3$ tons $O_2$. For the northern Bay (CB 1-5), every unit addition of P from external sources will yield 4 units of P-based production during summer, producing 4 x 106 units of carbon with a potential oxygen demand of 2.5 x carbon (= 1000 units O) or 500 units $O_2$. To reduce the oxygen demand by $14 \times 10^3$ tons, P should be reduced by $14 \times 10^3$ divided by 500 to equal 30 tons P. Similarly, for nitrogen, the load to the Bay needs to be reduced by $14 \times 10^3$ tons divided by 60 to equal 400 tons. It is probaby much more realistic to assume that only a fraction of the carbon produced actually is totally oxidized (say 50 percent), and that only a fraction (say 50 percent) of each nutrient is utilized. In that case, 120 tons P and/or 1,600 tons N reduction would be required to produce one aeration volume (from 0 to 2.0 ml $L^{-1}$). The computed reductions in nutrient loads are only 3 percent of the annual N load and 11 percent of the annual P load from the Susquehanna River to the Bay.

The point of the above exercise is to demonstrate that the DO content of deep waters of the Bay is very sensitive to changes in external nutrient supply. These small changes in external load cannot be detected by existing monitoring programs. Further, these small nutrient additions need not come from the Susquehanna River; they are such a small proportion that they could be advected from further down Bay or from adjacent tributaries. Finally, the CBP has no feeling for the importance of the timing of the nutrient additions. It cannot be said that a load reduction of 120 tons of P over the year is adequate or if all of the reduction must come, for example, from the spring load. It can be concluded, however, that to improve the deep water dissolved oxygen levels, nutrient inputs to the main Bay must be reduced.

## RELATIONSHIP TO FISHERIES

Nutrient-related food web shifts can affect the well-being of fish species (Ryther 1954). Nutrient enrichment can also affect fish through changes in dissolved oxygen profiles. Growth of oyster larvae ceases when dissolved oxygen concentrations reach 1.7 ml $L^{-1}$; adults can survive up to five days at concentrations of 0.7 ml $L^{-1}$ or less, but undergo stressful anaerobic metabolism (Galtsoff 1964). Sublethal oxygen stress can make oysters more susceptible to diseases.

As the volume of water containing low dissolved oxygen increases, the depth at which oysters can survive becomes shallower. This results in loss of potential oyster habitat. For example, if the depth of low dissolved oxygen changed from 10 meters to 9 meters depth, approximately 221 million square meters of potential oyster habitat would be lost from segment CB-4. As indicated in Table 5, the area of Chesapeake Bay bottom covered by low dissolved oxygen has increased since 1950; as a result there have been significant losses of potential oyster habitat.

TABLE 4. ESTIMATE OF NUTRIENT RECYCLING FOR CHESAPEAKE BAY -- (CB 1-5). ALL VALUES IN $10^6$ LBS. DATA FROM SMULLEN ET AL. 1982

| Minimum Recycling[1] | Spring | | Summer | | Fall | | Winter | |
|---|---|---|---|---|---|---|---|---|
| | N | P | N | P | N | P | N | P |
| Required to Support Production | 110 | 15 | 250 | 34 | 140 | 19 | 55 | 8 |
| Entering Bay | 108 | 7.4 | 59 | 12 | 55 | 4.5 | 78 | 6 |
| In Bay | 18 | 0.5 | 23 | 5 | 21 | 0.5 | 18 | 0. |
| Recycled [2] | 0 | 7.5 | 168 | 22 | 64 | 14 | -41 | 1. |
| % Recycled [3] | 0 | 50 | | | | | | |
| **Maximum Recycling[4]** | | | | | | | | |
| Required to Support Production | 110 | 15 | 250 | 34 | 140 | 19 | 55 | 8 |
| Entering Bay | 49.5 | 2.3 | 18 | 0.8 | 21 | 0.8 | 36 | 1. |
| In Bay | 18 | 0.5 | 23 | 5 | 21 | 0.5 | 18 | 0. |
| Recycled [2] | 42.5 | 12.2 | 209 | 28.2 | 98 | 17.7 | 1 | 5. |
| % Recycled | 38 | 80 | 83 | 82 | 70 | 93 | 1 | 73 |

[1] Assumes that all tributary nutrient loads from all sources reach the Bay.

[2] Required to Support Productivity (Entering + in Bay) = Recycled

[3] % Recycled = Recycled divided by required x 100

[4] Assumes that all tributary nutrient loads remain in tributaries and that the only Bay source is the Susquehanna River.

TABLE 5. AREA OF CHESAPEAKE BAY BOTTOM AFFECTED BY LOW DISSOLVED OXGYEN (DO) WATERS IN SUMMER; % = PERCENT OF BAY SEGMENTS CB 3, 4, AND 5 IMPACTED

| DO Level | July 1950 | | July 1969 | | July 1980 | |
|---|---|---|---|---|---|---|
| ml $L^{-1}$ | $m^2 x 10^6$ | % | $m^2 x 10^6$ | % | $m^2 x 10^6$ | % |
| 0.5 | 62.3 | 2.1 | 344.0 | 11.3 | 603 | 19.9 |
| 1.0 | 228.0 | 7.5 | 535.0 | 17.6 | 789 | 26.0 |
| 2.0 | 824.0 | 27.2 | 629.0 | 20.7 | 1196 | 39.4 |
| 3.0 | 1191.0 | 39.3 | 889.0 | 29.3 | 1417 | 46.7 |
| 4.0 | 1545.0 | 50.9 | 1455.0 | 48.0 | 2022 | 66.7 |

Dissolved oxygen is also important to the survival of finfish. Five ml $L^{-1}$ dissolved oxygen in surface waters is generally considered to be the minimum requirement for most sensitive species. This value is consistent with maintenance of 0.5 ml $L^{-1}$ at the bottom, as previously discussed. Lower oxygen concentrations may stress American shad, whose $LC_{50}$ is 3.6 ml $L^{-1}$ (Kaumeyer and Setzler-Hamilton 1982). To maintain a minimally diverse estuarine fishery, at least 2 to 3 ml $L^{-1}$ should be maintained (Thornton 1975).

## SECTION 6

# METHODOLOGY FOR DEVELOPING DEGREE OF METAL CONTAMINATION

## INTRODUCTION

Toxic substances may be naturally occurring materials, like lead, copper, or crude oil, which have been added to the estuary in harmful amounts by human activities. They may also include artificial materials, like Kepone, which are synthetically produced. These organic and inorganic materials may occur in bewildering varieties and forms in the Bay. Considerably less information is available about the relationship between specific toxic substances and their effects on Bay plants and animals, than is known about the nutrients nitrogen and phosphorus.

To assess trends for the occurrence of metals in Chesapeake Bay, one can use sediment cores which document changes over time. A sediment core, analyzed for trace metals and with an established geochronology, can be used to estimate trace metal inputs, assumming no diagenetic migration of metals through the length of the core. Such an analysis must be conducted carefully, for the burrowing activities of benthic organisms in oxic environments can disturb the sedimentary record, create an "artificial" $^{210}$Pb distribution, and influence trace metal patterns.

Several techniques have been devised to estimate the degree of contamination of sediments by metals. Turekian and Wedepohl (1961) developed data on the average concentration of trace metals in various sedimentary rocks. Often contamination in modern sediments is identified by the ratio of metal in the sample to metal in an average shale (or sandstone); this ratio is termed the Wedephol ratio. The problem with this technique is that there is no compelling evidence that natural James River sediments, for example, should have the same concentration of a particular metal as the average of all of the earth's shales. Other investigators have chosen to normalize trace metal concentrations to some metal present in sediments in such high concentrations that it is unlikely that anthropogenic sources could influence it to a significant degree.

The metal frequently chosen to ratio against is iron. Unfortunately, iron is relatively mobile after burial, and significant quantities can migrate through sediment pore waters. Still other investigators suggest normalizing the metal content of sediment samples to the grain size of the sediment. There is usually a strong inverse correlation between sediment size and metal content. Grain size, though, is only a rough indicator of particle surface area, sediment organic content, and sediment mineralogy, any or all of which are the probable cause of high metal concentration in fine sediments.

Chesapeake Bay Program scientists have applied a different approach to the estimation of the degree of metal contamination in Chesapeake Bay sediments. By using pre-colonial Chesapeake sediments, the use of potentially mobile metals like iron has been avoided; by measuring silicon and aluminum, sediment grain size and mineralogy have been accounted for simultaneously (sands are mostly quartz, and silts, [as size terms], and

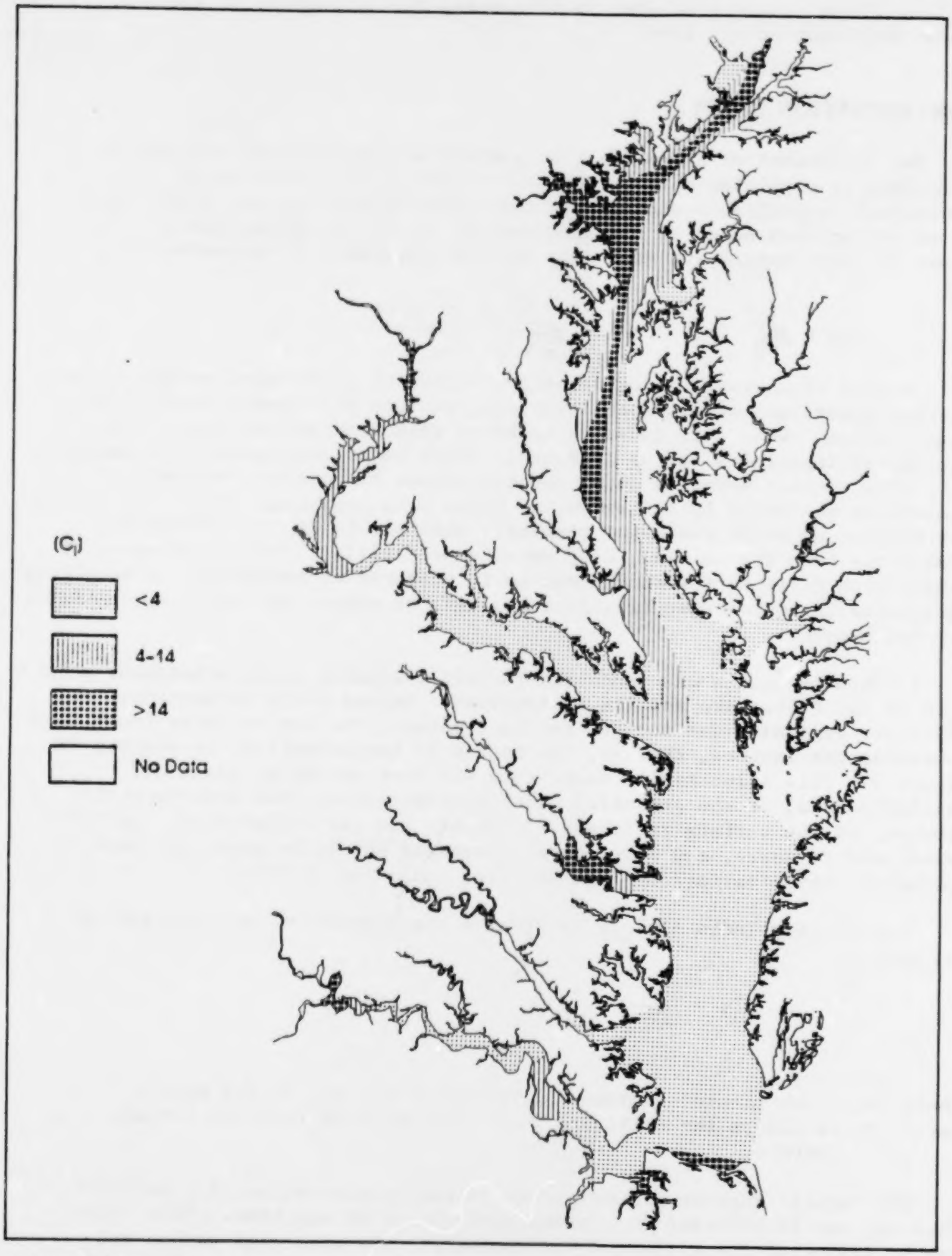

Figure 9. Degrees of metal contamination in the Bay based on the Contamination Index ($C_I$).

clays may be either quartz or clay minerals). A detailed discussion of the rationale and assumptions used in developing the Contamination Index is found in Flemer et al. 1983.

## CONTAMINATION INDEX

The Contamination Index ($C_I$) for surface sediments by metals can be developed by combining data on the anthropogenic concentration of individual contaminants and summing these contaminant factors ($C_f$). The $C_f$ value for each metal is computed and all of the $C_f$ values for a given sediment sample are summed to produce the index of contamination, $C_I$:

$$C_I = \sum_{n=1}^{n} C_f = \sum_{n=1}^{n} \frac{C_o - C_p}{C_p}$$

This method of characterizing estuarine sediments gives equal weight to all metals, regardless of absolute abundance, and has no inherent ecological significance. When this index is combined with bio-toxicity data, its biological importance can be assessed. Where individual metal $C_f$'s exceed 1.0, they contain specific metal concentrations that exceed natural Chesapeake sediments by 100 percent. These $C_f$'s are based on the correlation of Si/Al and metal content. They should be interpreted as departures from the natural, deep metal concentration. The correlation of metals with Si/Al ratios should not be interpreted as causation. Controlling parameters for metal concentrations may well be redox, pH, organic, or sulfur species present.

A computer search was conducted for all available surface sediment metals data in the Chesapeake and its tributaries. Values could be developed to calculate contamination factors for each metal. The sum of these individual contamination factors, that is, the degree of contamination, is plotted in Figure 9. This illustration represents our best estimate, using all available data, of the potential metal contamination, from anthropogenic sources, of the surface sediments of the Bay and its tributaries. No data exist near to shore, and large local increases should be expected close to outfalls. These variations have not been indicated on Figure 9.

The Toxicity Index closely relates to the Contamination Index and is defined as:

$$T_I = \sum_{i=1}^{i=6} \frac{M_1}{M_i} \cdot Cf_i$$

where $M_i$ = the "acute" anytime EPA criterion for any of the metals,
but $M_1$ is always the criterion value for the most toxic of the six metals.

The "acute" anytime EPA criterion is the concentration of a material that may not be exceeded in a given environment at any time. This value may be different for different environments. The criterion values are calculated by standardized procedures using data from in-house EPA studies and from published scientific literature (U.S. EPA 1982b). The details of the method are explained in Appendix D of Flemer et al. 1983.

The Toxicity Index was calculated for every station where the Contamination Index was calculated. Each station was given an average salinity value based upon its geographical location and available salinity data (Stroup and Lynn 1963). Because the toxicity of metals is often greater in freshwater than in salt water, each station was characterized by its minimum salinity. Bottom salinities were used in every case. Freshwater stations were those with salinities less than 0.5 ppt, and these were assigned criterion values for freshwater at 50 ppm hardness. Brackish stations were those with salinities between 0.5 and 5.0 ppm, and these were assigned criterion values for freshwater with a hardness of 200 ppm. Stations with salinities greater than 5.0 ppt were assigned criterion values for salt water.

A contour map of Toxicity Indices using logarithmic intervals again shows a high level of contamination in Baltimore Harbor, but with the apparently associated high indices in the adjacent main Bay, restricted largely to the axis of the Bay (Figure 10). Additionally, the sediments in much of the lower James River are relatively uncontaminated by toxic metals; only those sediments off Norfolk and near Portsmouth are highly contaminated. Comparison of contour maps of $C_I$ versus $T_I$ reveals areas of similarity, as would be expected. In general, however, the Toxicity Index map shows more details of structure and variation within an area than does the $C_I$ map. Areas of greatest toxicity, such as Baltimore Harbor, an area extending northward to the Susquehanna Flats, the Northeast River, the lower Rappahannock, upper York, and the Elizabeth River, are also most contaminated using the $C_I$ method. In addition, the lower Patuxent River and several smaller tributaries of the lower James have high Toxicity Indices. Moderately high values of the $T_I$ occupy the central and upper Bay main stem and lower reaches of most western shore tributaries, except the James River. In general, this pattern follows the distribution of finer sediments in Chesapeake Bay, which is not unexpected, as heavy metals are associated with the silt and clay fraction of the substrate.

Though a contour map based on logarithmic intervals allows a general analysis of metal contamination of the Bay's sediments, the Toxicity Index at stations within a contour interval can vary greatly, especially within the interval containing the highest values. Toxicity Indices for stations in Baltimore Harbor range from 3.2 to 2,691.4 and reflect considerable differences in the expected toxicity of the sediments.

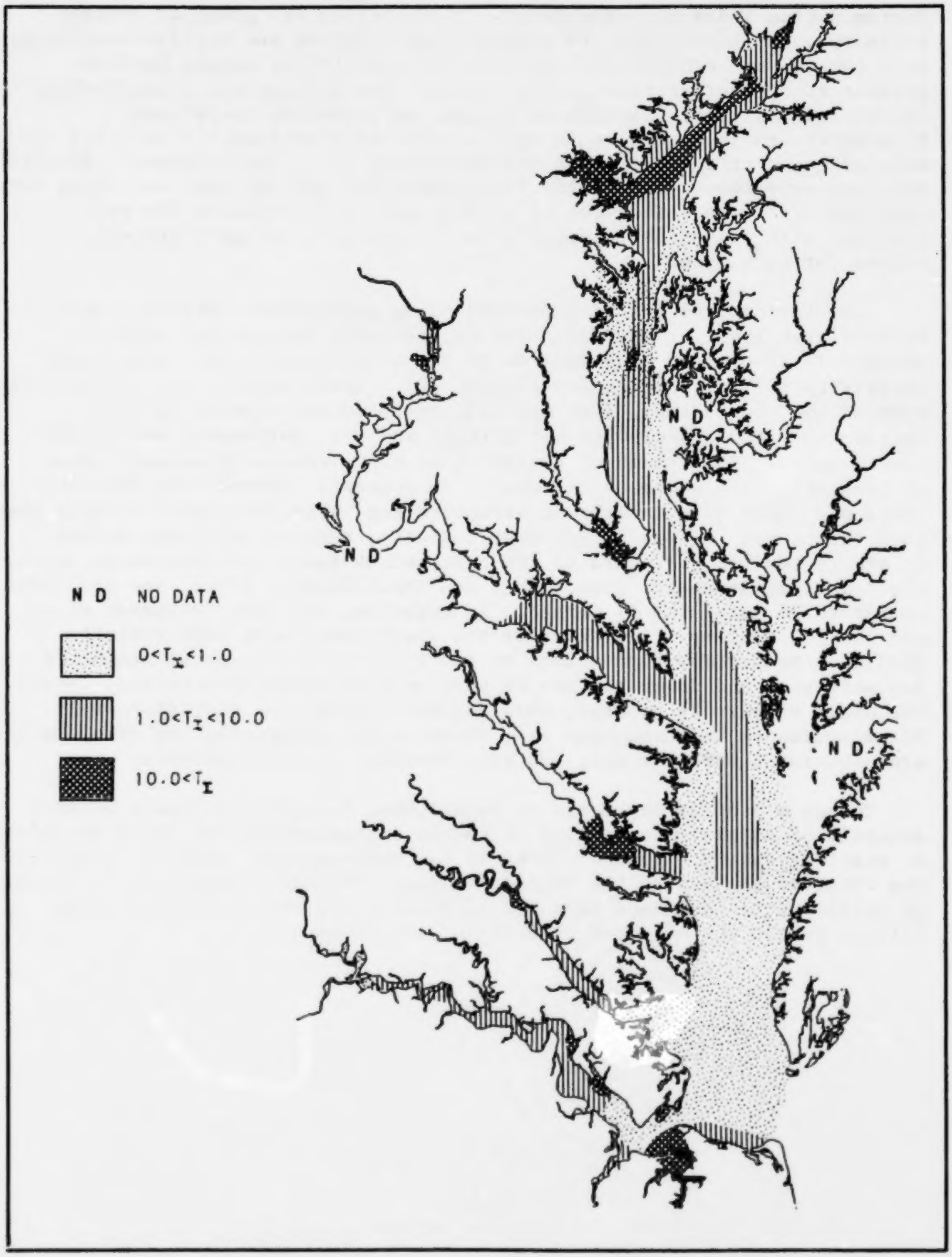

Figure 10. Toxicity Index of surface sediments in Chesapeake Bay.

## SECTION 7

# DISCUSSION AND CONCLUSIONS

This appendix provides a management focus on information used in the development of a classification or ranking scheme of environmental factors associated with the distribution and abundance of the biota. This approach provides a mechanism to integrate information that characterizes the requirements for growth, reproduction, survival, and migration of the biota. Once a "target level" of an environmental factor (e.g., nutrients and toxic substances in our analysis) is identified, then managers have a better basis to decide if the factor should be controlled. Control implies decisions regarding human use which inherently involves human value judgements. In this context, scientific information is used to define relational aspects among variables and management exercises the perogrative of defining levels of use or application of terms such as good, bad, or fair.

As a cautionary note, it is important to understand that the relationships discussed in this chapter are largely correlative in nature. There exists the possibility and, indeed, the probability, that under different environmental conditions the relationships will change. It is the nature of this change that future studies are likely to provide an increased understanding.

In summary, Table 6 is provided for easy reference and a synthesis of information described in the text. These "target levels" are offered with the assurance that future work will improve their scientific basis. They are preliminary and over-drawing their meaning and ignoring the substantial uncertainty associated with them as guidance will only serve to deceive the user.

It should be noted that little information is available to make first-order estimates of the relationship between living resources, and water and sediment quality factors. Under some circumstances, meeting up-estuary target levels will benefit the down-estuary problem; however, lower estury regions are also under the influence of more seaward regions because of the two-layer circulation pattern in much of the Bay system. Recognizing these constraints, the CBP has nonetheless made an attempt to develop target criteria for nutrients and toxic substances. Table 7 provides the best estimate of the relationship between these criteria and environmental quality objectives. Broad ranges between classes, as well as the small number of classes, illustrates the lack of precision in setting class limits. It is anticipated that both accuracy and precision can be improved dramatically in the near future.

TABLE 6. SOME RELATIONSHIPS BETWEEN LIVING RESOURCES, SYSTEM FEATURES, NUTRIENTS, AND TOXIC MATERIALS

| Resource Variable | Environmental Variable | | |
|---|---|---|---|
| | Toxicity Index | Dissolved Oxygen | Nutrients |
| Diverse open water fishery (tidal freshwater and oligohaline waters) | | 5 mg $L^{-1}$<br>(3.6 ml $L^{-1}$) | 0.6 mg $L^{-1}$ - TN<br>0.1 mg $L^{-1}$ - TP |
| SAV[1] (oligohaline to mesohaline waters) | | | 0.6 mg $L^{-1}$ - TN<br>0.1 mg $L^{-1}$ - TP |
| Oysters[2] (mesohaline waters of main-Bay) | | 2.5 mg $L^{-1}$<br>(1.8 ml $L^{-1}$) | 0.35 mg $L^{-1}$ - TN<br>0.04 mg $L^{-1}$ - TP |
| Minimially diverse finfishery (tidal freshwater and oligahaline waters) | | 4 mg $L^{-1}$<br>(2.9 ml $L^{-1}$) | TBD |
| Surface sediments (selected biota) | Low (1.0)<br>Medium (1.0 to 10.0)<br>High (10.0) | | |
| York River-like | | | 0.7 mg $L^{-1}$ - TN<br>0.06 mg $L^{-1}$ - TP |

Note: approximately 6.3 mg $L^{-1}$ DO (4.5 mg $L^{-1}$) above the pycnocline is required to maintain 0.7 mg $L^{-1}$ DO (0.5 ml $L^{-1}$) at the bottom of the deep channel of the main Bay.

[1] Will require slight but yet undetermined reduction in levels of TN and TP in tidal-freshwaters over 0.6 mg $L^{-1}$ TN and 0.1 mg $L^{-1}$ TP.

[2] Approximation based on the assumption that mid-1960's data represent a nominal excursion of oxygen-limiting waters onto the mid-Bay shelf. This estimate needs further calibration.

TABLE 7. A FRAMEWORK FOR THE CHESAPEAKE BAY ENVIRONMENTAL QUALITY CLASSIFICATION SCHEME

| Class | Quality | Objectives | Quality | $T_I$ | TN | TP |
|---|---|---|---|---|---|---|
| A | Healthy | supports maximum diversity of benthic resources, SAV, and fisheries | Very low enrichment | 1 | 0.6 | 0.08 |
| B | Fair | moderate resource diversity reduction of SAV, chlorophyll occasionally high | moderate enrichment | 1-10 | 0.6-1.0 | 0.08-0.14 |
| C* | Fair to Poor | a significant reduction in resource diversity, loss of SAV, chlorophyll often high, occasional red tide or blue-green algal blooms | high enrichment | 11-20 | 1.1-1.8 | 0.15-0.20 |
| D | Poor | limited pollution-tolerant resources, massive red tides or blue-green algal blooms | significant enrichment | 20 | 1.8 | 0.20 |

Note: $T_I$ indicates Toxicity Index;
TN indicates Total Nitrogen in mg $L^{-1}$;
TP indicates Total Phosphorus in mg $L^{-1}$.

*Class C represents a transitional state on a continuum between classes B and D.

SECTION 8

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# APPENDIX B

# NUTRIENT SOURCES AND LOADINGS

Joseph Macknis
Mary E. Gillelan
Caren E. Glotfelty

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# POPULATION DATA FOR THE CHESAPEAKE BAY BASIN

## METHODOLOGY

Population statistics were compiled for the years 1950 to 2000 for the Chesapeake Bay basin and its major sub-basins. Historical estimates (1950 through 1980) were derived from the U.S Population Census. The following sources of data on population projections (1990 and 2000) include state estimates based upon the 1980 Census, unless noted otherwise:

| | |
|---|---|
| Delaware | Office of Management, Budget, and Planning |
| District of Columbia | Bureau of Economic Analysis, U.S. Dept. of Commerce |
| Maryland | Department of State Planning |
| New York | New York Department of Environmental Conservation |
| Pennsylvania | Department of Environmental Resources |
| Virginia | Department of Planning and Budget |
| West Virginia | Department of Economic and Community Development |

The state projections used have been approved by the EPA for use in water quality management planning. Data for counties situated in more than one sub-basin were converted to sub-basin level data in proportion to the estimated county land area in each sub-basin; data for Pennsylvania were aggregated to the sub-basin level by a more accurate analysis by the state.

The data have been aggregated in the following tables:
Table 1-- Chesapeake Bay Basin Population, 1950 to 2000;
Table 2-- Chesapeake Bay Basin Population by State;
Table 3-- Chesapeake Bay Basin Population Above and Below the Fall Line;
Table 4-- Chesapeake Bay Basin Population by Major River Basin; and
Table 5-- Chesapeake Bay Basin Population by Minor Sub-basin.

Data in Table 5 have been plotted in Figure 1 through Figure 16 to illustrate trends.

TABLE 1. CHESAPEAKE BAY BASIN POPULATION, 1950 TO 2000 (IN THOUSANDS)

| 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|
| 8,447.5 | 10,018.7 | 11,772.3 | 12,652.6 | 13,743.6 | 14,567.4 |

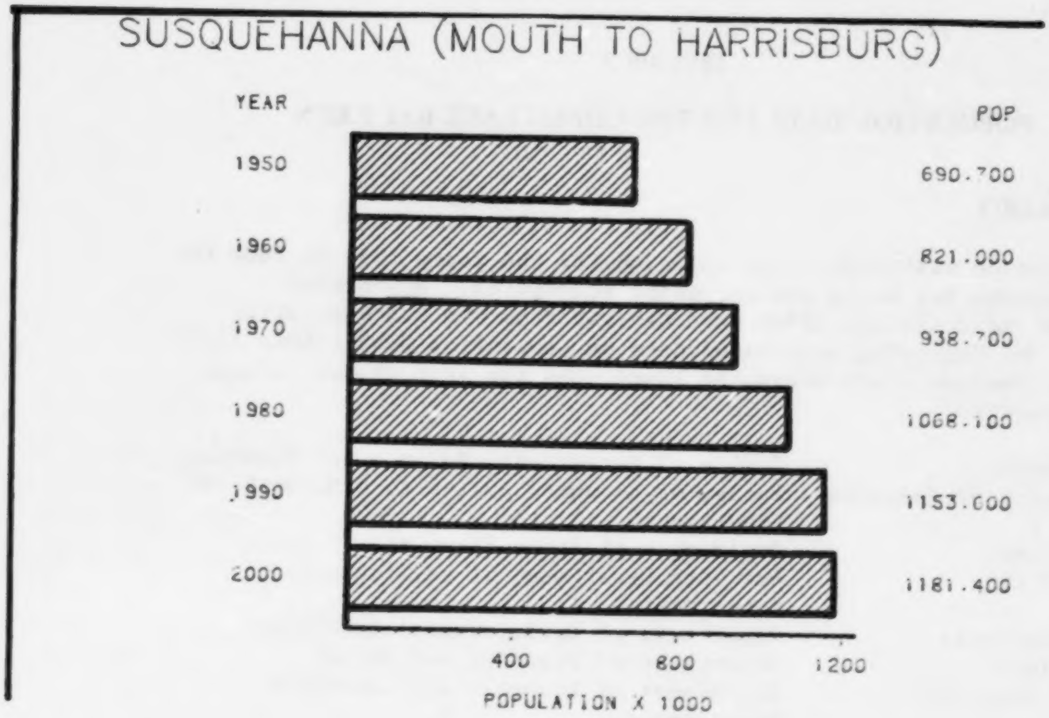


Figure 1. Population trends from 1950 to 2000 in the Susquehanna basin (mouth to Harrisburg)

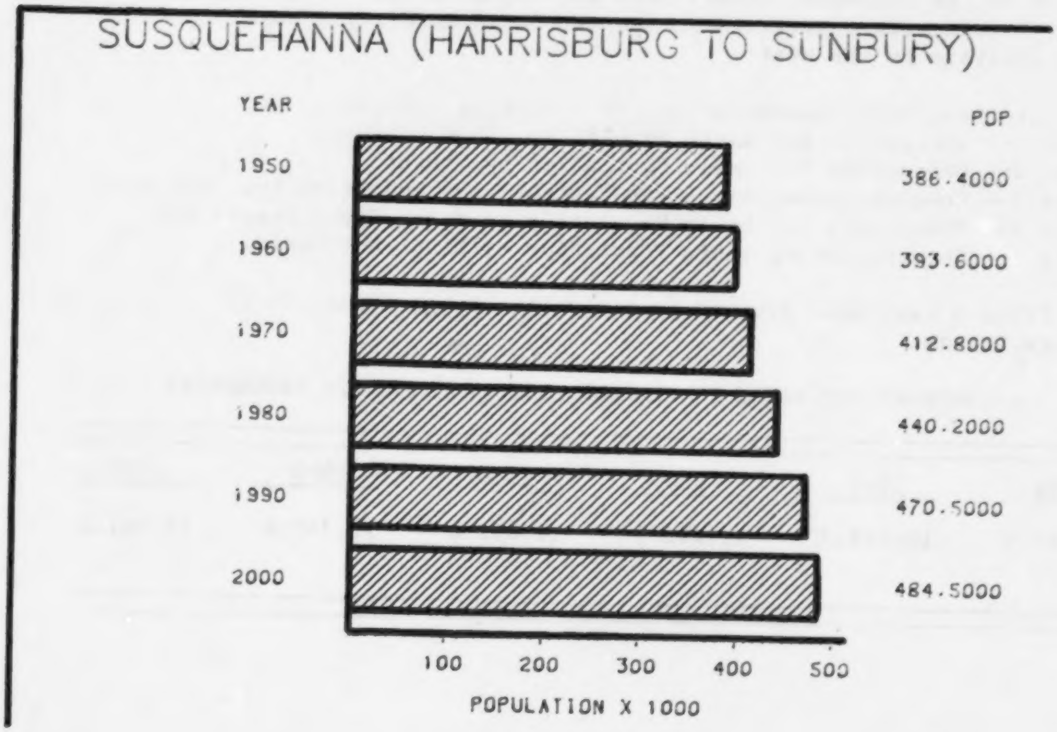


Figure 2. Population trends from 1950 to 2000 in the Susquehanna basin (Harrisburg to Sunbury)

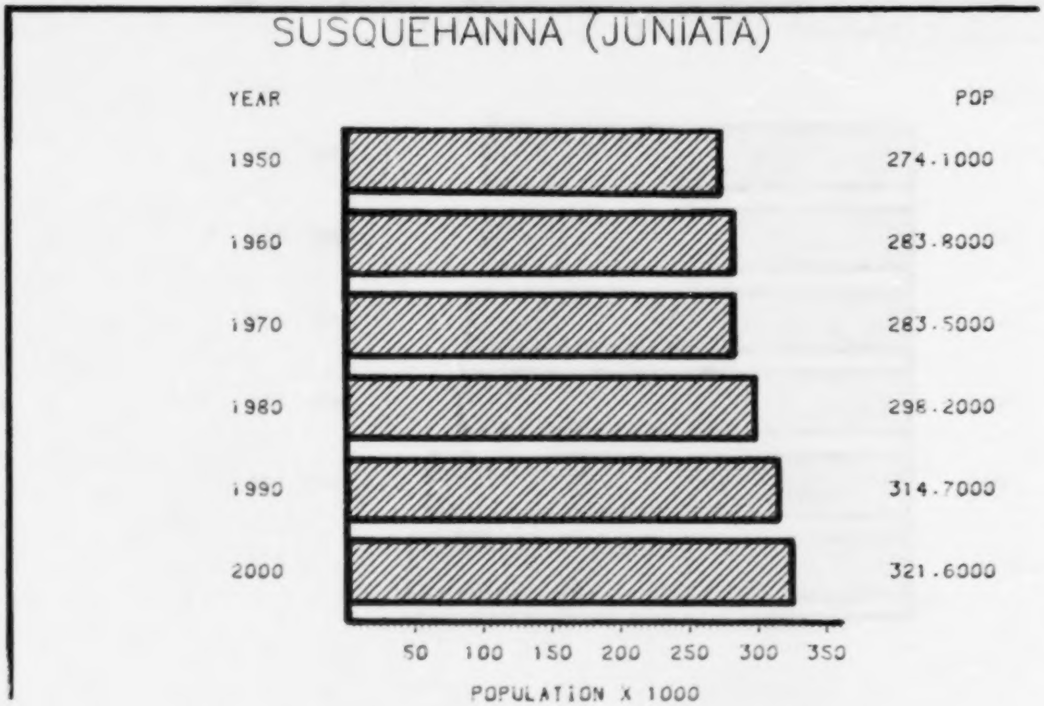


Figure 3. Population trends from 1950 to 2000 in the Susquehanna basin (Juniata sub-basin)

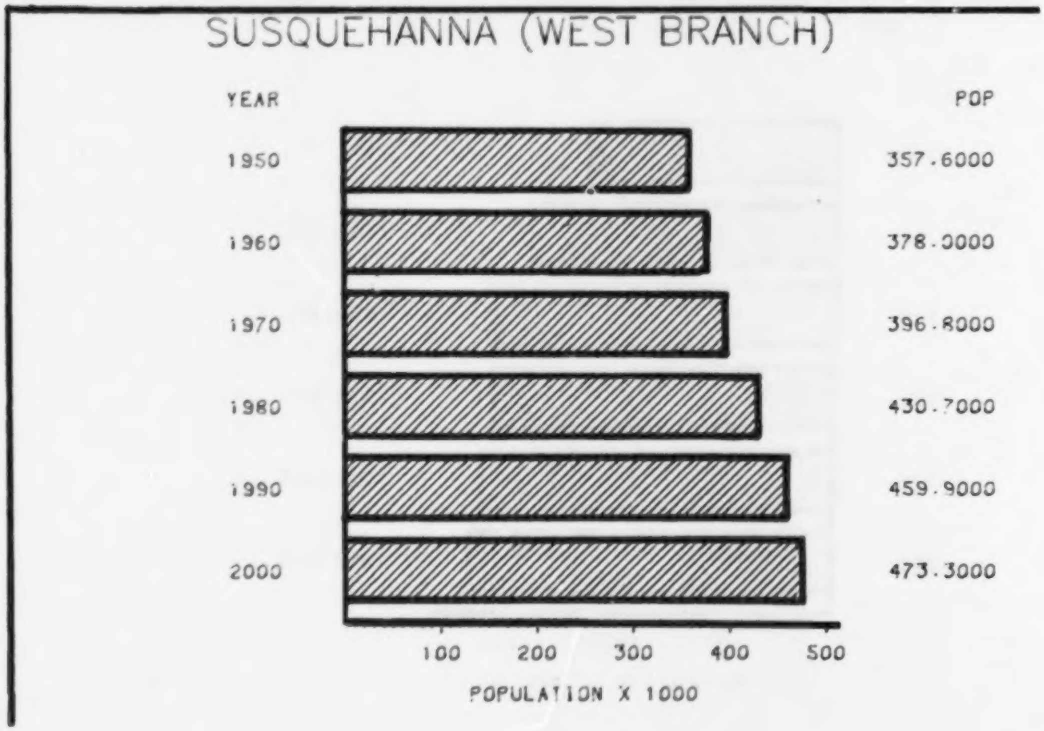
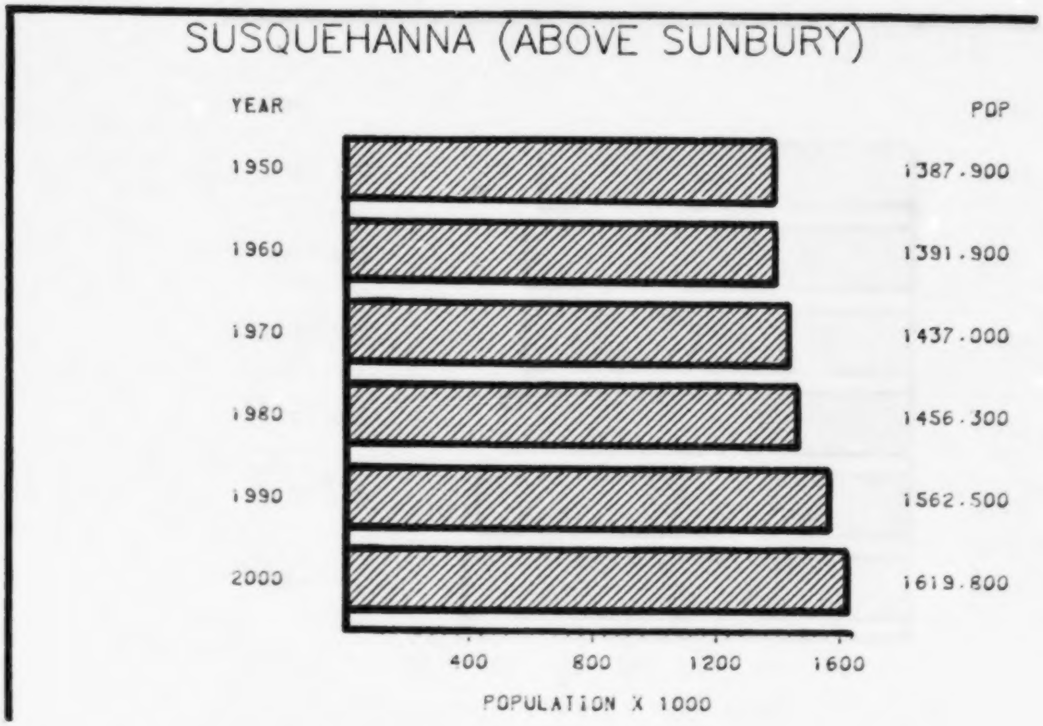


Figure 4. Population trends from 1950 to 2000 in the Susquehanna basin (West branch)



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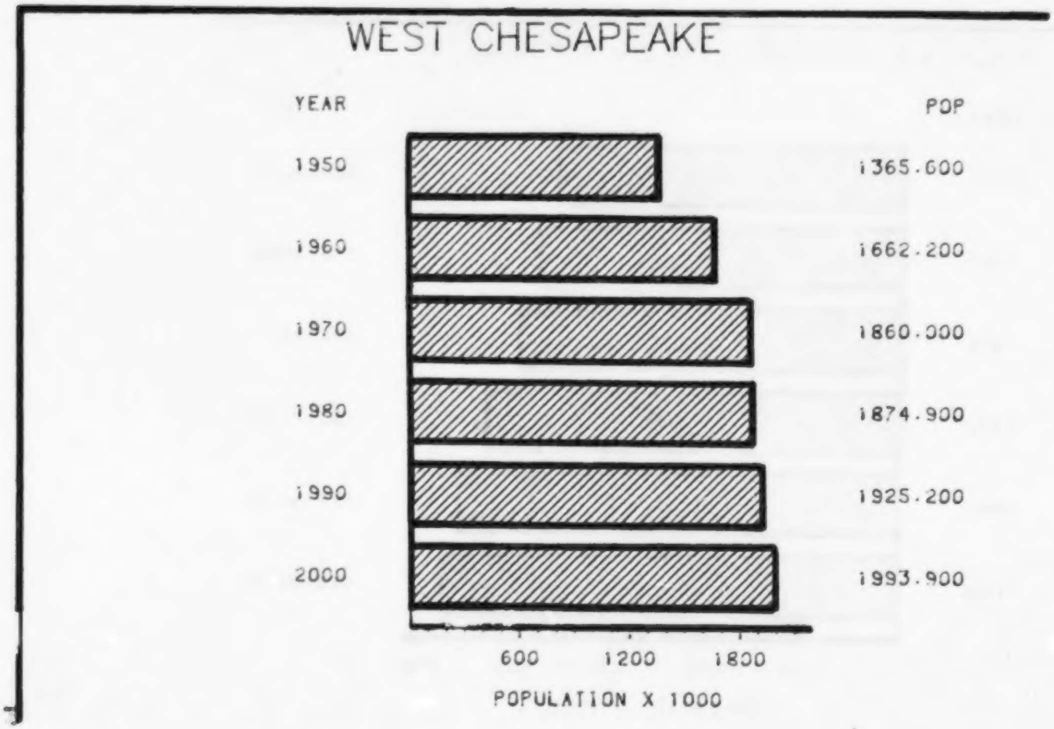


Figure 6. Population trends from 1950 to 2000 in the West Chesapeake basin

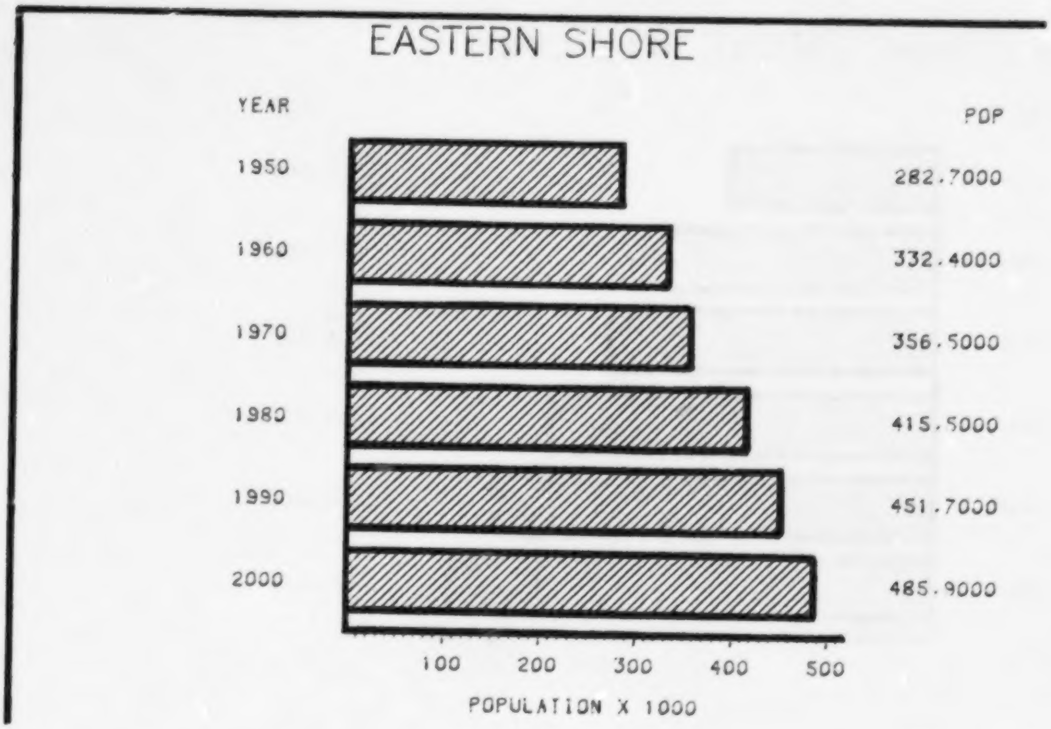


Figure 7. Population trends from 1950 to 2000 in the Eastern Shore basin

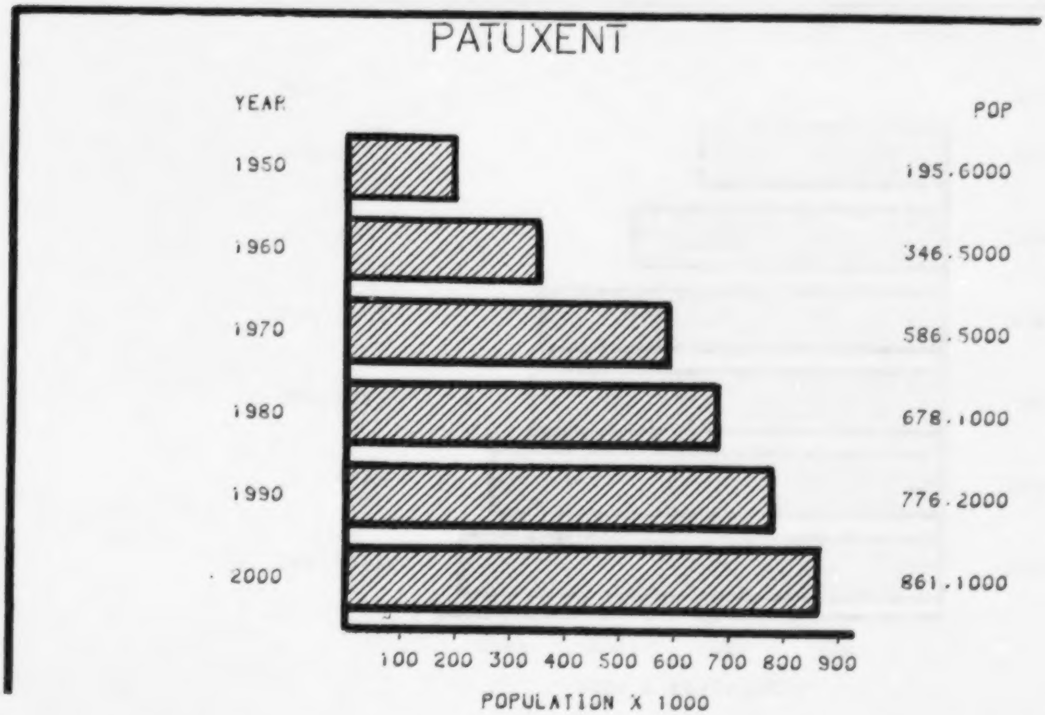


Figure 8. Population trends from 1950 to 2000 in the Patuxent basin .

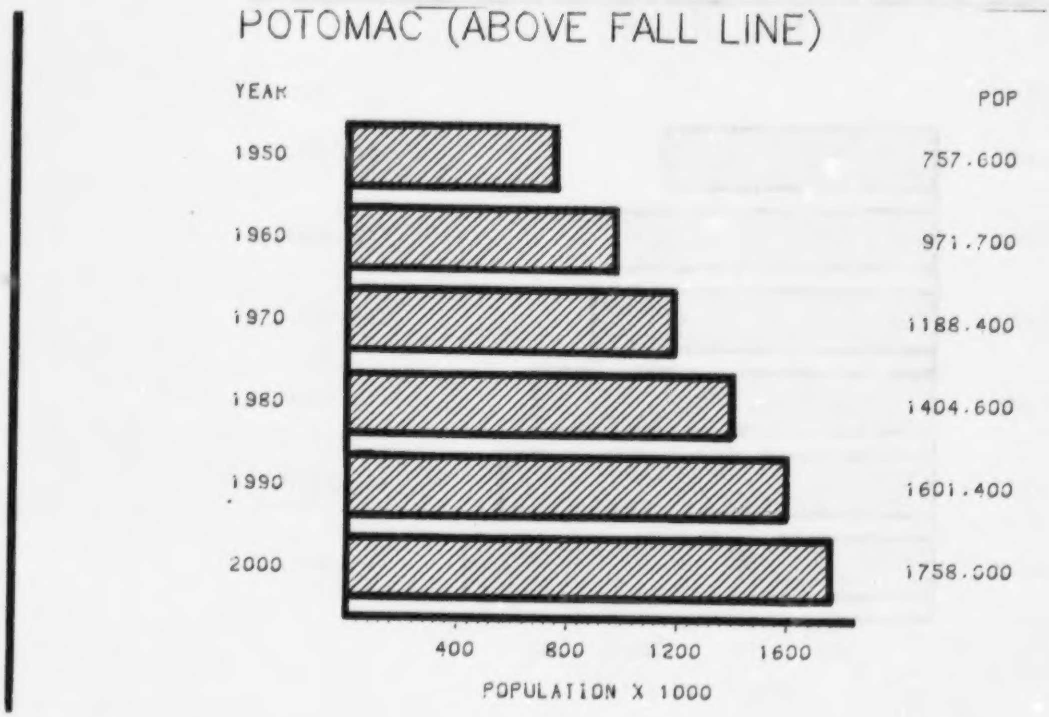


Figure 9. Population trends from 1950 to 2000 in the Potomac (above the fall line)

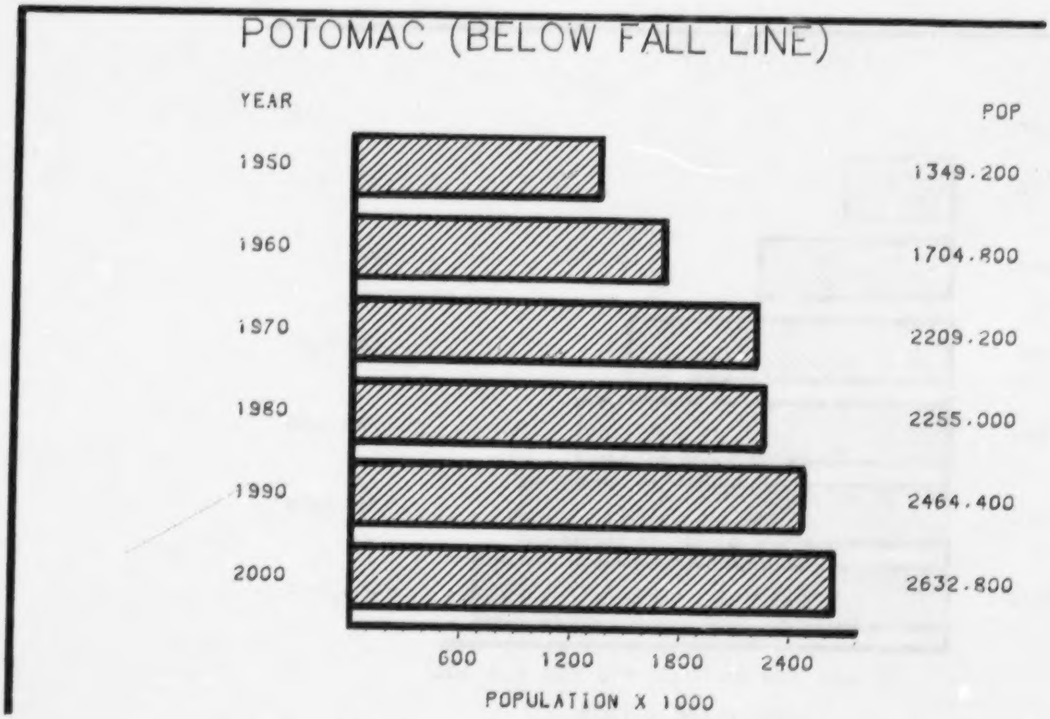


Figure 10. Population trends from 1950 to 2000 in the Potomac (below the fall line)

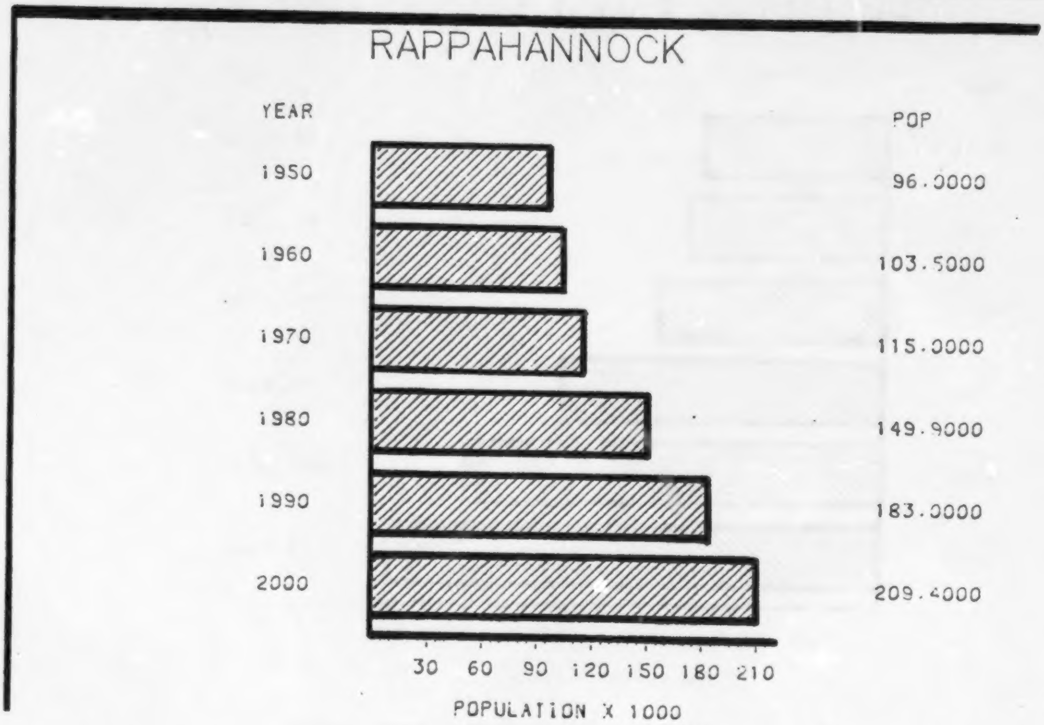


Figure 11. Population trends from 1950 to 2000 in the Rappahannock basin

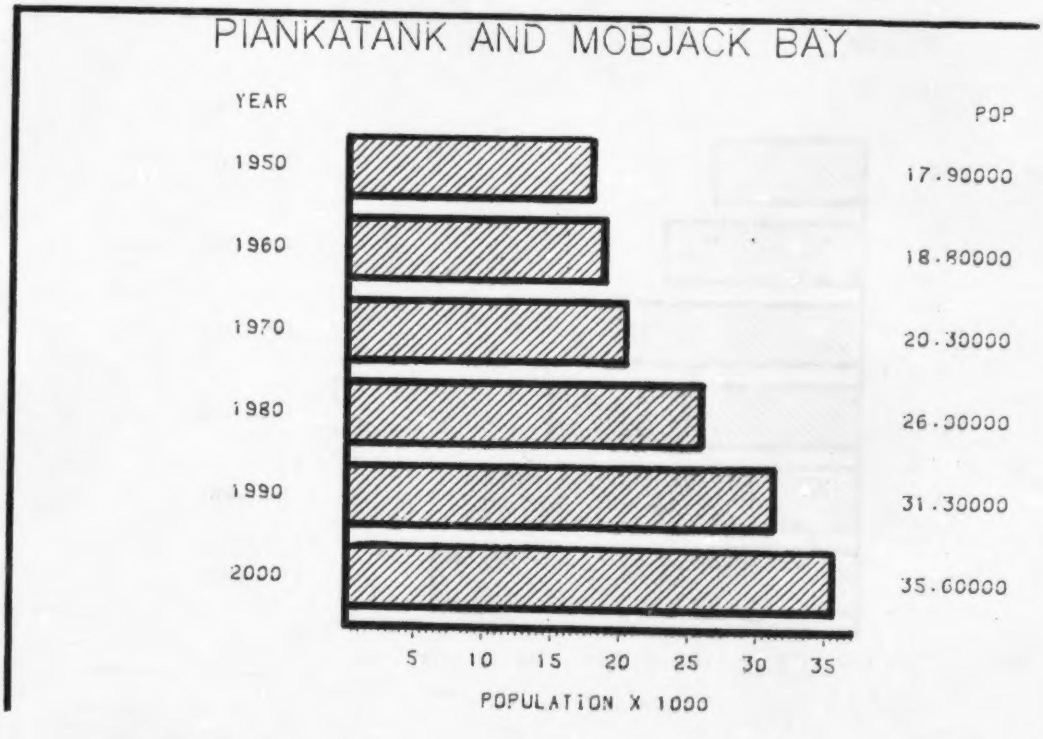


Figure 12. Population trends from 1950 to 2000 in the Piakatank River and Mobjack Bay

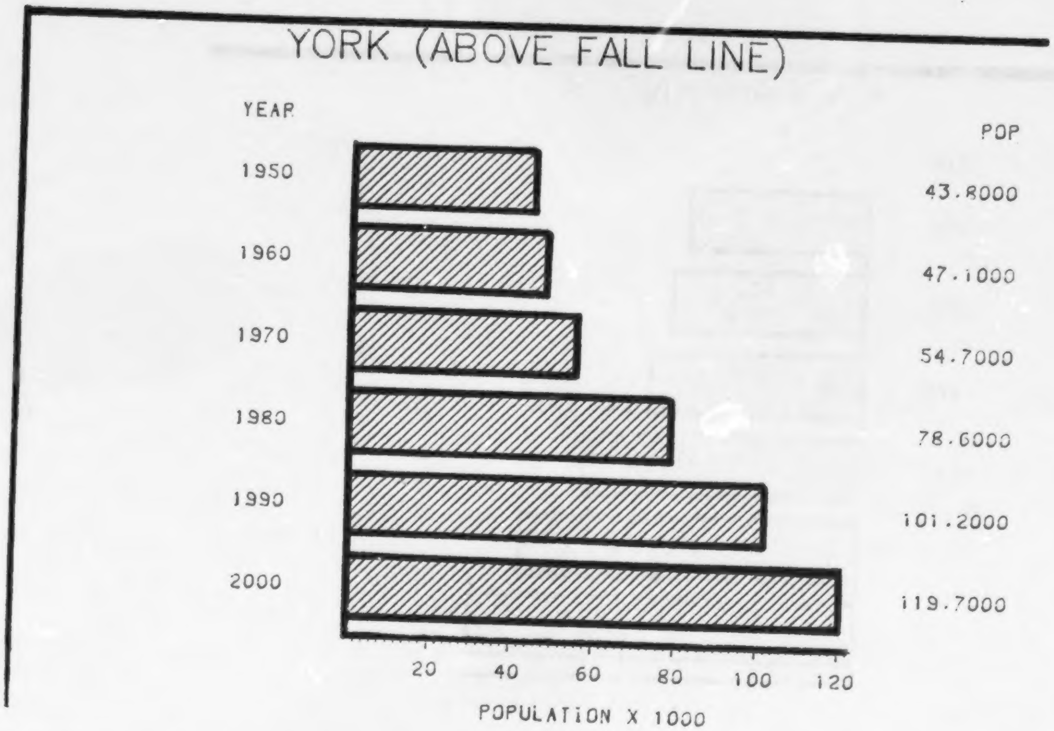


Figure 13. Population trends from 1950 to 2000 in the York basin (above the fall line)

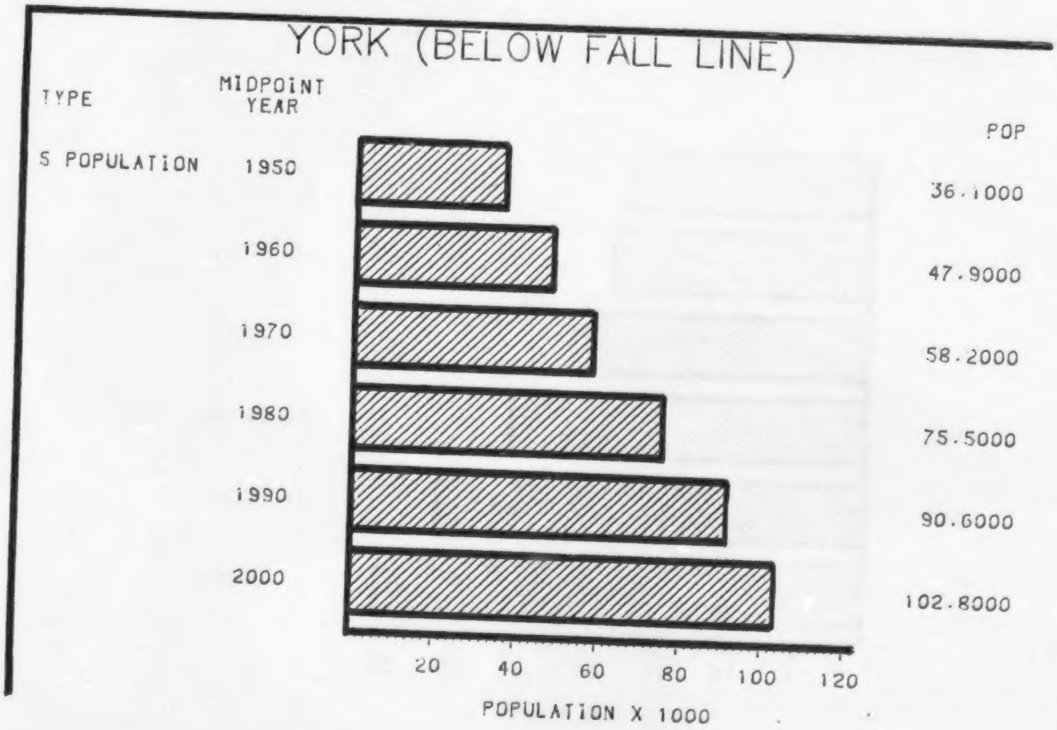


Figure 14. Population trends from 1950 to 2000 in the York basin (below the fall line)

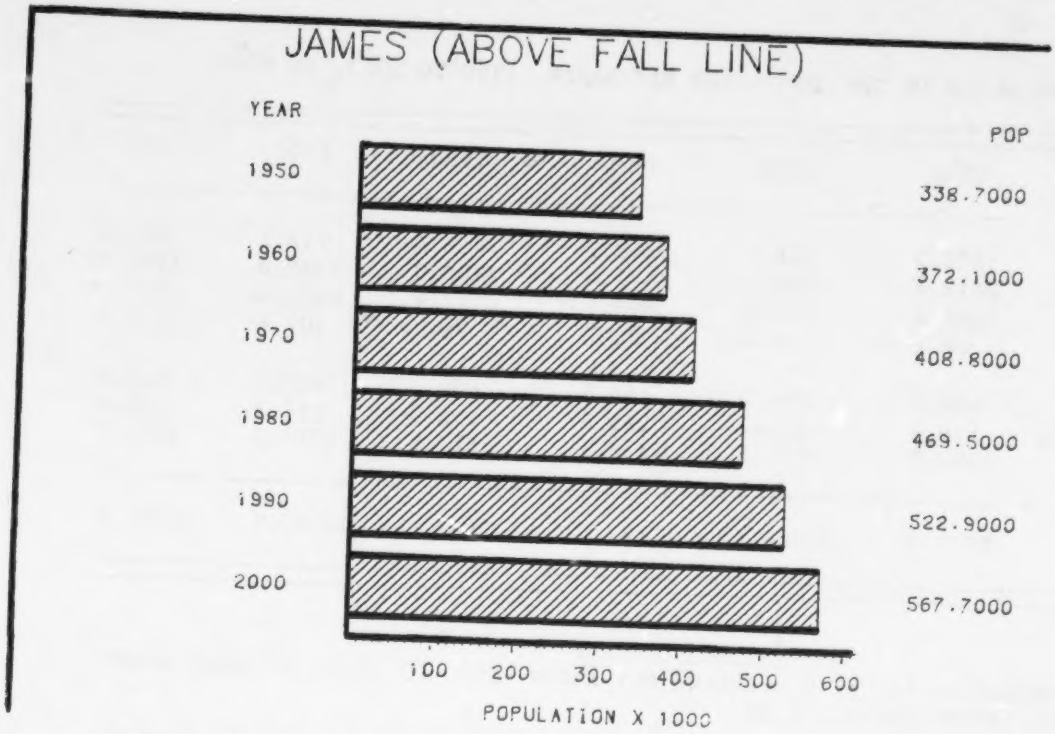


Figure 15. Population trends from 1950 to 2000 in the James basin (above the fall line)

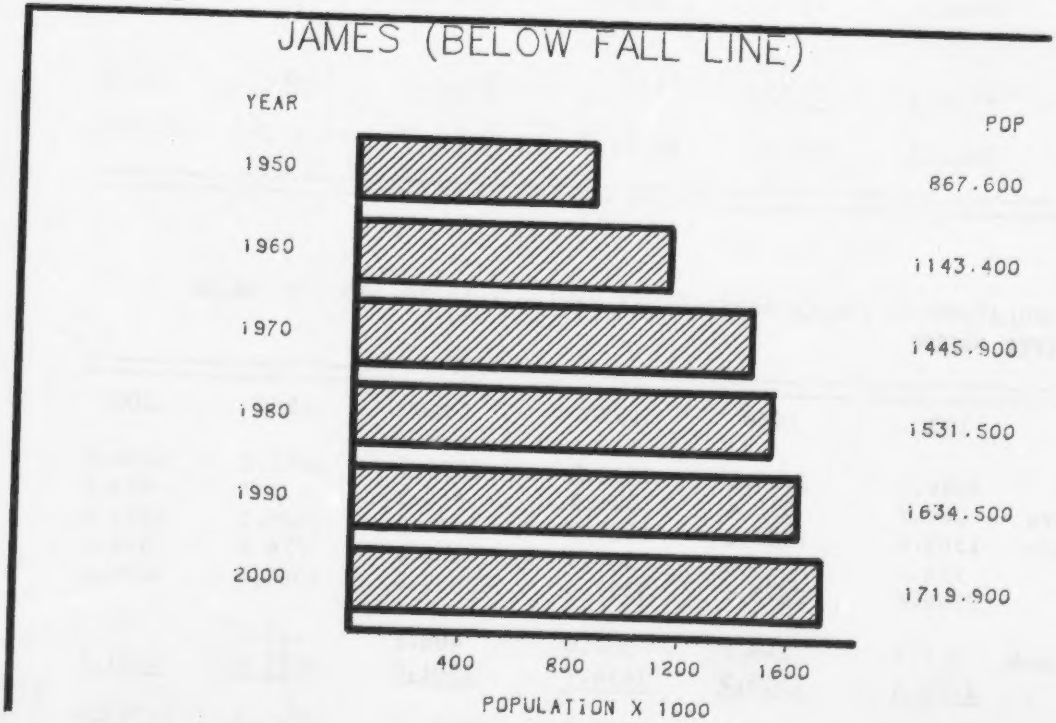


Figure 16. Population trends from 1950 to 2000 in the James basin (below the fall line)

TABLE 2. POPULATION IN THE CHESAPEAKE BAY BASIN, 1950 TO 2000, BY STATE

| (in 000's) | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| New York | 551.3 | 616.8 | 656.1 | 658.8 | 718.1 | 755.0 |
| Pennsylvania | 2613.7 | 2720.0 | 2877.4 | 3102.0 | 3312.0 | 3393.8 |
| Maryland | 2319.8 | 3074.9 | 3893.9 | 4187.9 | 4476.0 | 4727.4 |
| Delaware | 48.8 | 71.2 | 84.7 | 98.1 | 107.6 | 121.7 |
| District of Columbia | 802.2 | 764.0 | 756.5 | 634.0 | 632.0 | 626.0 |
| West Virginia | 118.9 | 120.7 | 125.5 | 158.0 | 193.1 | 228.8 |
| Virginia | 1992.8 | 2651.1 | 3378.2 | 3813.8 | 4304.8 | 4714.7 |
| Total | 8447.5 | 10018.7 | 11772.3 | 12652.6 | 13743.6 | 14567.4 |

TABLE 3. POPULATION IN THE CHESAPEAKE BAY BASIN, 1950 TO 2000, BY AREAS ABOVE AND BELOW THE FALL LINE

| (in 000's) | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| Above the Fall Line | 4288.2 | 4715.2 | 5184.9 | 5732.3 | 6293.9 | 6649.8 |
| Below the Fall Line | 4159.3 | 5303.5 | 6587.4 | 6920.3 | 7449.7 | 7917.6 |
| Total | 8447.5 | 10018.7 | 11772.3 | 12652.6 | 13743.6 | 14567.4 |

TABLE 4. POPULATION IN THE CHESAPEAKE BAY BASIN, 1950 TO 2000, BY MAJOR RIVER BASIN

| (in 000's) | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| Susquehanna | 3096.7 | 3268.3 | 3468.8 | 3693.5 | 3961.2 | 4080.6 |
| Eastern Shore | 282.7 | 332.4 | 356.5 | 415.5 | 451.7 | 485.9 |
| W. Chesapeake | 1365.6 | 1662.2 | 1860.0 | 1874.9 | 1925.2 | 1993.9 |
| Patuxent | 195.6 | 346.5 | 586.5 | 678.1 | 776.2 | 851.1 |
| Potomac | 2106.8 | 2676.5 | 3397.6 | 3659.6 | 4065.8 | 4390.8 |
| York-Rappahannock | 217.3 | 248.2 | 330.0 | 406.1 | 467.5 | |
| James | 1206.3 | 1515.5 | 1854.7 | 2001.0 | 2157.4 | 2287.6 |
| Total | 8447.5 | 10018.7 | 11772.3 | 12652.6 | 13743.6 | 14567.4 |

TABLE 5. POPULATION IN CHESAPEAKE BAY BASIN, 1950 TO 2000 (IN THOUSANDS), BY MINOR BASINS

| Minor Basin | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| Susquehanna | | | | | | |
| above Sunbury | 1387.9 | 1391.9 | 1437.0 | 1456.3 | 1562.5 | 1619.8 |
| West Branch | 357.6 | 378.0 | 396.8 | 430.7 | 459.9 | 473.3 |
| below Harrisburg | 690.7 | 821.0 | 938.7 | 1068.1 | 1153.6 | 1181.4 |
| Sunbury-Harrisburg | 386.4 | 393.0 | 412.8 | 440.2 | 470.5 | 484.5 |
| to Juniata | 274.1 | 283.8 | 263.5 | 298.2 | 314.7 | 321.6 |
| Eastern Shore | 282.7 | 332.4 | 356.5 | 415.5 | 451.7 | 485.9 |
| West Chesapeake | 1365.6 | 1662.2 | 1860.0 | 1874.9 | 1925.2 | 1993.9 |
| Patuxent | 195.6 | 346.5 | 586.5 | 678.1 | 776.2 | 861.1 |
| Potomac | | | | | | |
| above the fall line | 757.6 | 971.7 | 1188.4 | 1404.6 | 1601.4 | 1758.0 |
| below the fall line | 1349.2 | 1704.8 | 2209.2 | 2255.0 | 2464.4 | 2632.8 |
| Rappahannock | | | | | | |
| above the fall line | 51.4 | 56.0 | 64.2 | 86.1 | 107.2 | 123.8 |
| below the fall line | 44.6 | 47.5 | 50.8 | 63.8 | 75.8 | 85.6 |
| York | | | | | | |
| above the fall line | 43.8 | 47.1 | 54.7 | 78.6 | 101.2 | 119.7 |
| below the fall line | 36.1 | 47.9 | 58.2 | 75.5 | 90.6 | 102.8 |
| Piankatank and Mobjack Bay | 17.9 | 18.8 | 20.3 | 26.0 | 31.3 | 35.6 |
| James | | | | | | |
| above the fall line | 338.7 | 372.1 | 408.8 | 469.5 | 522.9 | 567.7 |
| below the fall line | 867.6 | 1143.4 | 1445.9 | 1531.5 | 1634.5 | 1719.9 |

SECTION 2

# LAND-USE METHODOLOGY AND DATA

It is difficult, if not impossible, to derive precise land-use statistics for the Chesapeake Bay basin. There is as yet no accepted national system, and states and lower political sub-divisions tend to collect land-use information only sporadically, using many different methods. As with population, land use is rarely compiled by watershed. (The exception is the Maryland Automated Geographic Information System (MAGI) used by the State of Maryland).

Gaining a picture of past land-use trends is difficult because of the lack of information prior to the early 1970's. Reliable information even for the recent past is not consistently available throughout the watershed. The first land-use mapp of the Bay was done experimentally by the USGS as part of the CARETS project. This information was used by the Corps of Engineers in their existing conditions study but, unfortunately, it does not exist for the whole basin. The figures are by county, and there is some question about the accuracy of this data.

More recently, the USGS has mapped land use for all of the states in the basin, but has only generated statistics for Pennsylvania, Delaware, District of Columbia, West Virginia, and a small portion of Maryland. This analysis is known as The Land Use and Land Cover System and is related to an earlier system called LUDA.

Maryland has had a computerized land-use information system, MAGI since 1973. New York has had a similar system, LUNA. Virginia has had no state land-use inventory. Pennsylvania has helped finance data analysis of the USGS Land Use and Land Cover System for state needs.

Although there is no consistent accounting of land-use trends in the Chesapeake Bay Basin, several sources of information do indicate major shifts in land use throughout the region. Statistics on agricultural land-use have been collected using surveys and other methods by the Census Bureau since the mid 1800's. In addition, the U.S. Forest Service has been conducting periodic state forest resource surveys since the 1940's. Because there are some biases in the data from these sources, it is misleading to compare them directly with data obtained from maps. These surveys are, however, reasonable estimates and are internally consistent because data have been collected using similar methods over time.

These two sources were used to develop a set of consistent, basin-wide land-use statistics (on cropland, pasture land, forest land, and other land) which indicate major shifts in land use. Data are reported by county in the two sources described above. With the adjustment factors used in the population analysis, data for each county that drains to more than one sub-basin were disaggregated in proportion to the county land area in each sub-basin.

Census of Agriculture data are collected every four or five years. For this analysis, the 1949, 1959, 1964, 1969, 1978 records were used to represent 1950, 1960, 1965, 1970, and 1980, respectively. The land-use data in the 1969 Census of Agriculture were collected using sampling techniques that differed from other Census years, so this data set was not used to look at trends. To construct trends, estimates were extrapolated from adjacent record years to represent agricultural land use in 1955, 1970, and 1975. Total cropland was calculated as the sum of two of three census cropland categories, "cropland harvested" and "cropland not harvested and not pastured," excluding "cropland used only for pasture." This third land use was added to "woodland pastured" and "other pasture" to represent total pasture land. Farmland reported in the Census and not included in this analysis was contained in the categories "woodland not pastured" and "other land." The "total cropland" and "total pastureland" shown in the Census, therefore, would not agree with the CBP estimates.

The U.S. Forest Service has been conducting periodic state forest resource surveys since the 1940's. Surveys conducted for the states in the Chesapeake Bay basin are shown below in Table 6. Unfortunately, surveys were not conducted on a regular basis as in the Census of Agriculture, so surveys closest to 1955, 1965, and 1975 were chosen to represent these years. For the trend analysis, it was assumed that 1950 forest cover was equal to 1955 and 1980 forest cover was equal to 1975 data. For 1960 and 1970, estimates were made by extrapolating from 1955, 1965, and 1975 data. Where no reliable Timber Survey or Census of Agriculture data existed, missing figures were estimated by extrapolation.

TABLE 6. U.S. FOREST SERVICE TIMBER SURVEYS CONDUCTED FOR BAY-AREA STATES BETWEEN 1950 AND 1980, AND USED TO CONSTRUCT LAND-USE TRENDS

| CBP Analysis Year | 1950 and 1955 | 1965 | 1975 and 1980 |
|---|---|---|---|
| Maryland Timber Survey | 1950 | 1964 | 1976 |
| Pennslyvania Timber Survey | 1955 | 1965 | 1978 |
| Virginia Timber Survey | 1957 | 1965 | 1976 |
| Delaware Timber Survey | — | 1972 | 1972 |
| West Virginia Timber Survey | — | — | 1975 |

Timber survey categories varied by state and year. They included total commercial; private, public, and non-commercial; and total forest land. Total forest land was used to indicate the percent forested land in the trend analysis. For counties covering more than one basin, adjustment factors (percent county land area in each sub-basin) disaggregated data to the sub-basin level.

Historical forest and agricultural data were then summarized for each county and sub-basin. The land in each county not accounted for by the Census of Agriculture or Timber Surveys was placed in the category called "other land". This catch-all category may include residential, commercial, other urban land uses, institutional land, wetlands, highways, idle, or other types of land uses. For example, two sub-basins have high (above 10 percent) percentages of "other" land in 1950 -- the Eastern Shore (21.0 percent), which has extensive wetlands, and the West Chesapeake basin, (14.7 percent) which encompasses the urbanized Baltimore and Annapolis region. The sub-basins which show the greatest increases in urban land from 1950 to 1980 are also those which experienced the greatest population growth (Potomac, Patuxent, and West Chesapeake).

Most of the increases in "other" lands between 1950 and 1980 are assumed to be due to growth in primarily residential, commercial, and other urban lands and, secondarily, to the establishment or expansion of military bases, other Federal lands, universities, and other institutions occupying large tracts of land. The tremendous growth of "other" land in the Patuxent basin (3.4 to 35.4), for example, may be accounted for by residential and commercial growth in the Laurel, Columbia, Bowie, Crofton, and Lexington Park areas, although expansion of institutional and public lands has also played an important role. Further analysis is needed to determine how much land acreage was established, and when, for the following (and compare this information with data of ground-breaking and expansion of towns noted above): Patuxent Naval Air Station, Patuxent Wildlife Research Center, Bowie State College, Fort Meade, Agricultural Research Center, Baltimore-Washington Parkway, Rocky Gorge, Tridelphia Dam, etc. The Eastern Shore "other" land increased by only one-third (20.7 to 30.1); however, the total rose 10 percentage points. Further analysis would help determine the primary land-use conversions in this area. In summary, the "other" land-use category is assumed to indicate the relative rates of urbanization throughout the Bay basin.

Historical land use estimates for cropland, pasture, forest, and other land uses are presented in Table 7 through Table 10, as follows:

Table 7 -- Estimated Land Use in the Chesapeake Bay Basin, 1950, 1955, 1960, 1965, 1970, 1975, 1980;
Table 8 -- Estimated Land Use in Major Sub-basins of the Chesapeake Bay, 1950 to 1980;
Table 9 -- Estimated Land Use in Minor Sub-basins of Chesapeake Bay Basin, 1950 to 1980;
Table 10 -- Estimated Land Use in Chesapeake Bay Basin, by State, 1950 to 1980; and
Table 11 -- Chesapeake Bay Basin Land Area, by State.

In addition, trends in each of the minor sub-basins are plotted in Figure 17 through Figure 32.

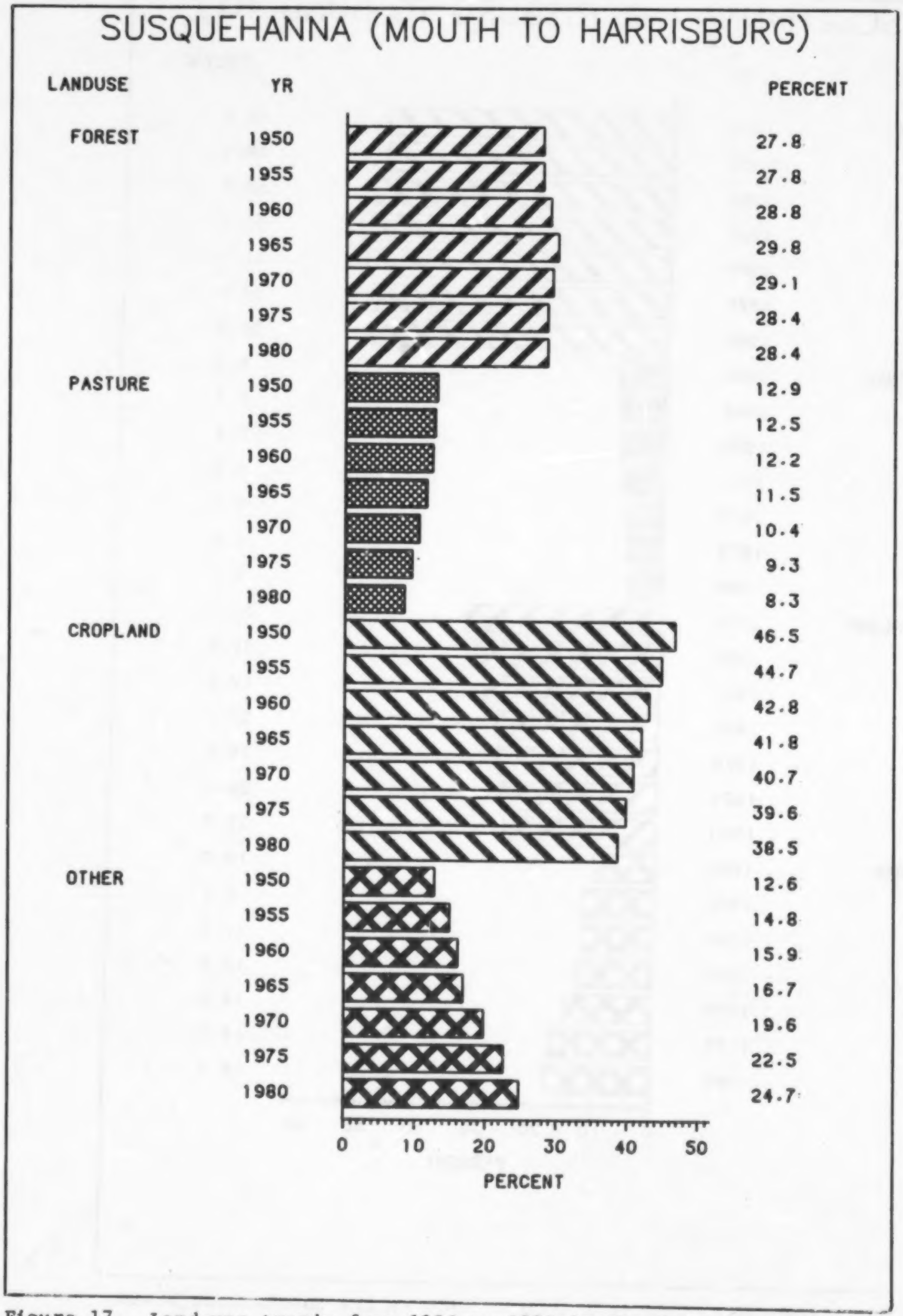


Figure 17. Land-use trends from 1950 to 1980 in the Susquehanna basin (mouth to Harrisburg)

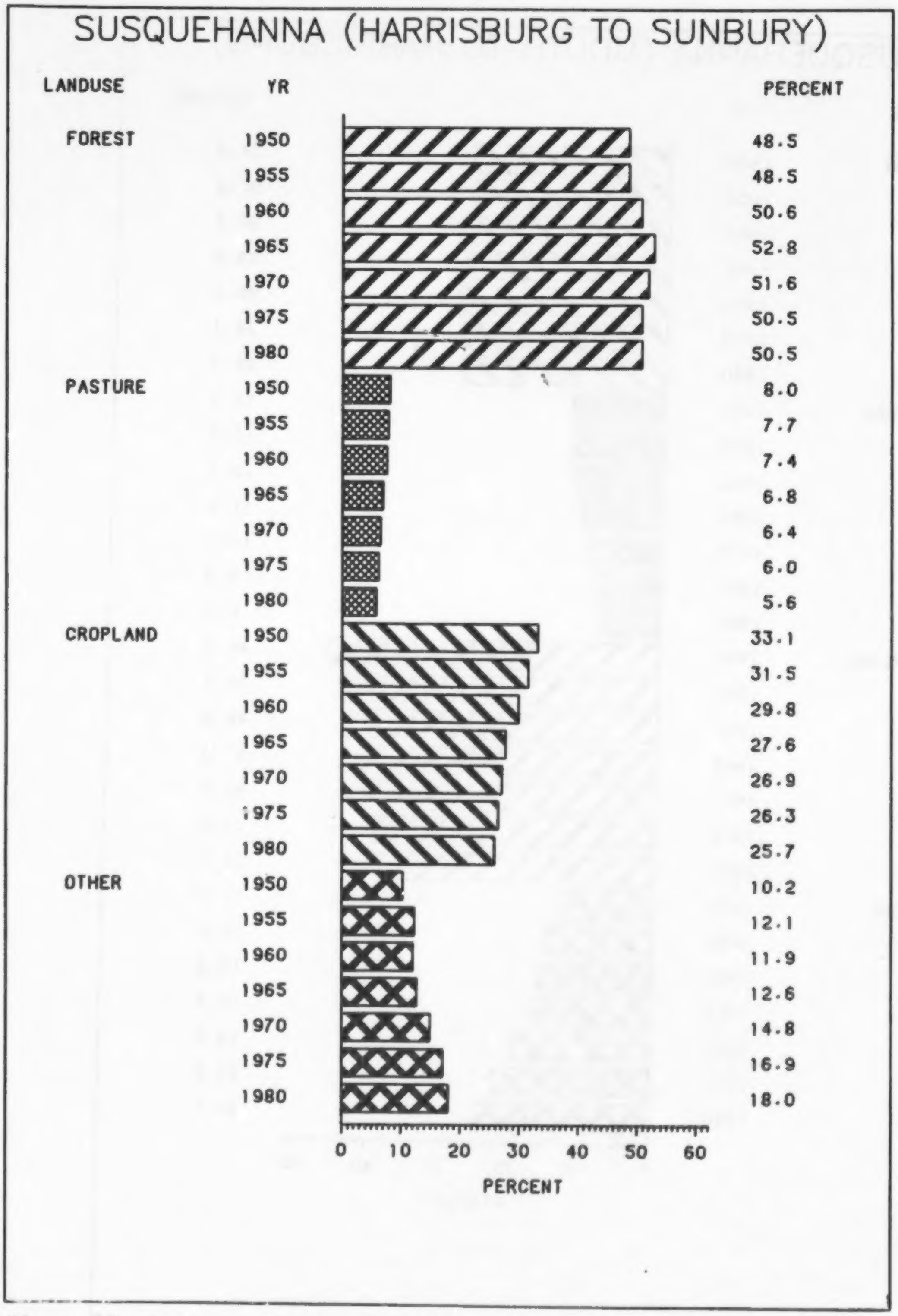


Figure 18. Land-use trends from 1950 to 1980 in the Susquehanna basin (Harrisburg to Sunbury)

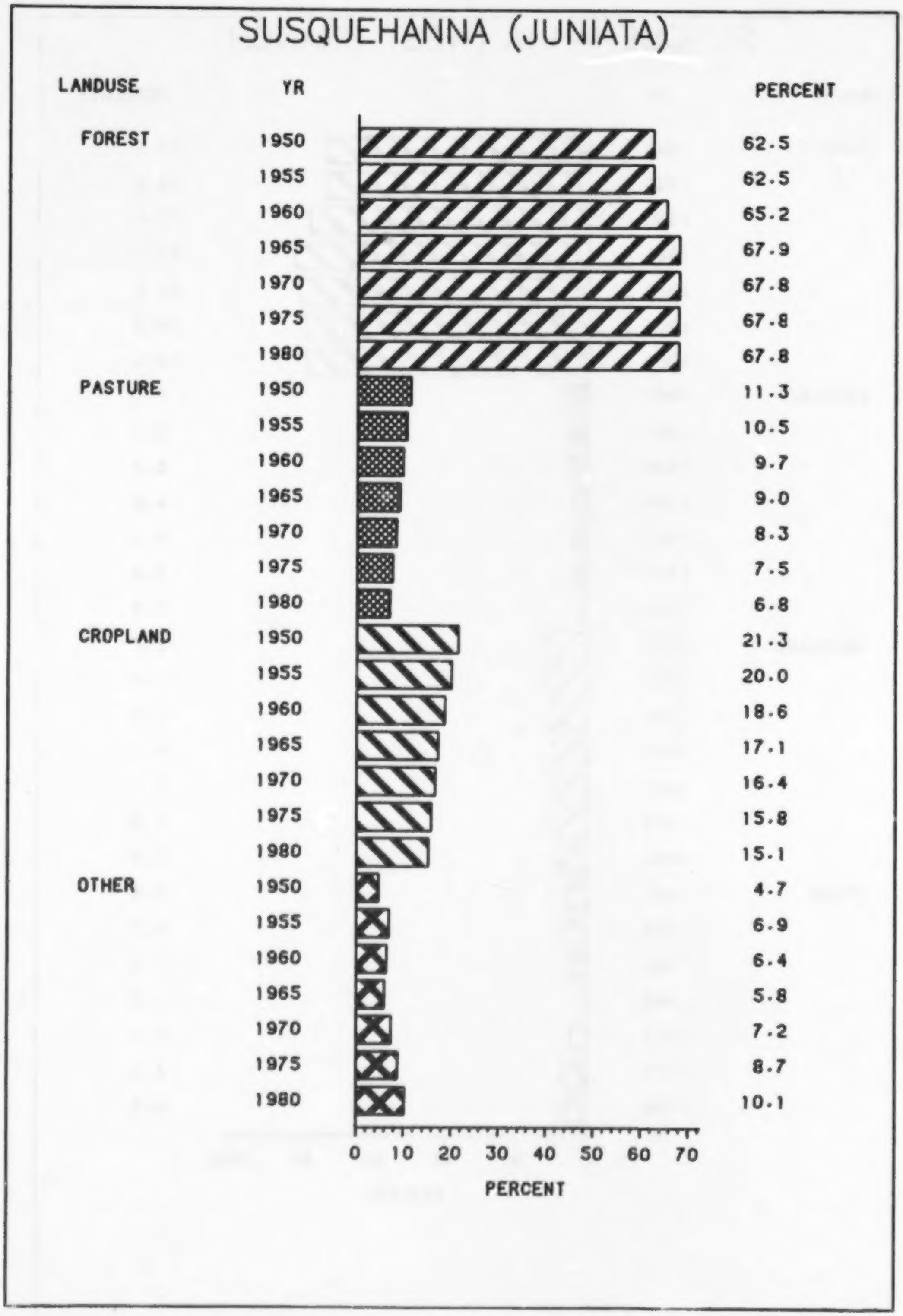


Figure 19. Land-use trends from 1950 to 1980 in the Susquehanna basin (Juniata sub-basin)

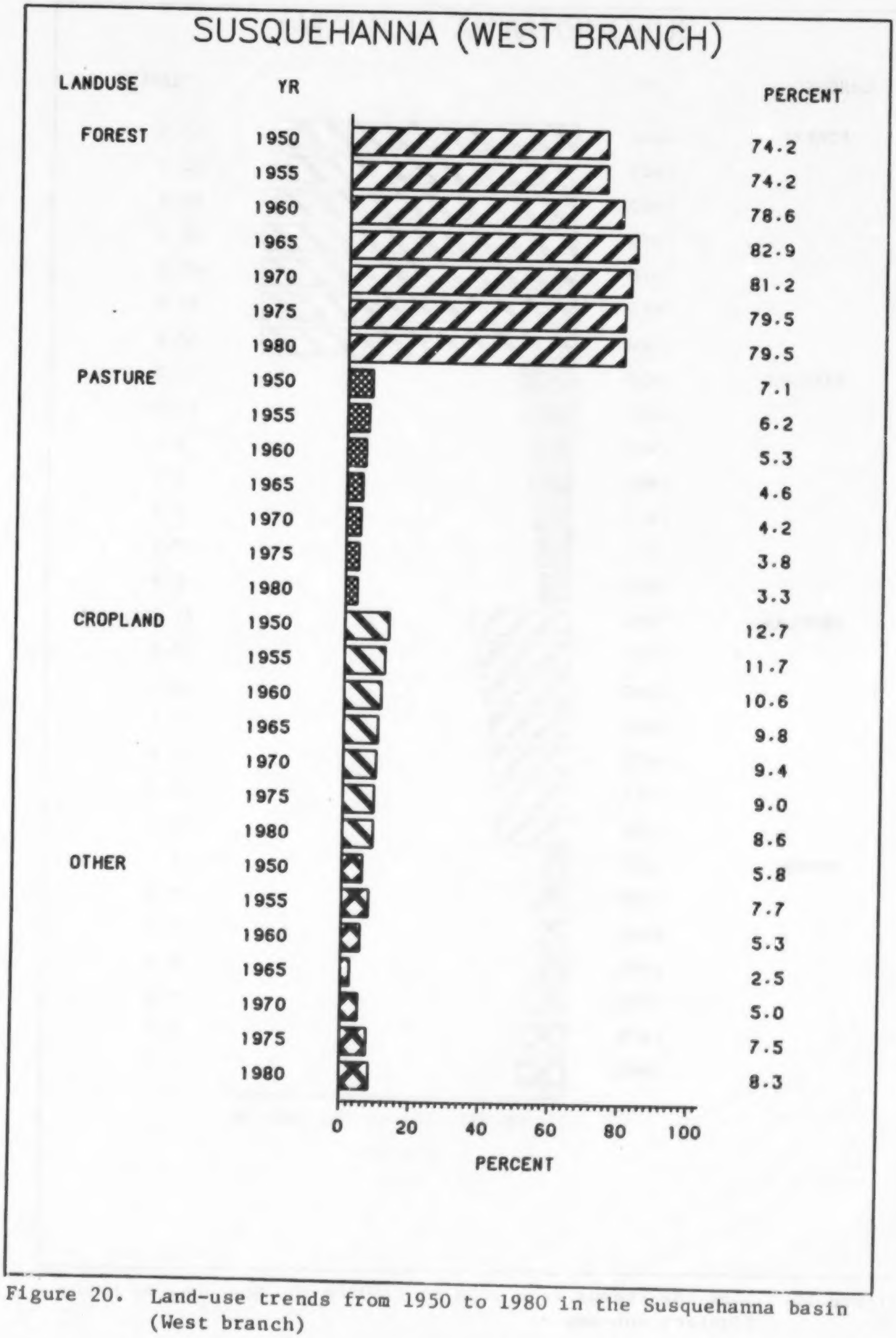


Figure 20. Land-use trends from 1950 to 1980 in the Susquehanna basin (West branch)

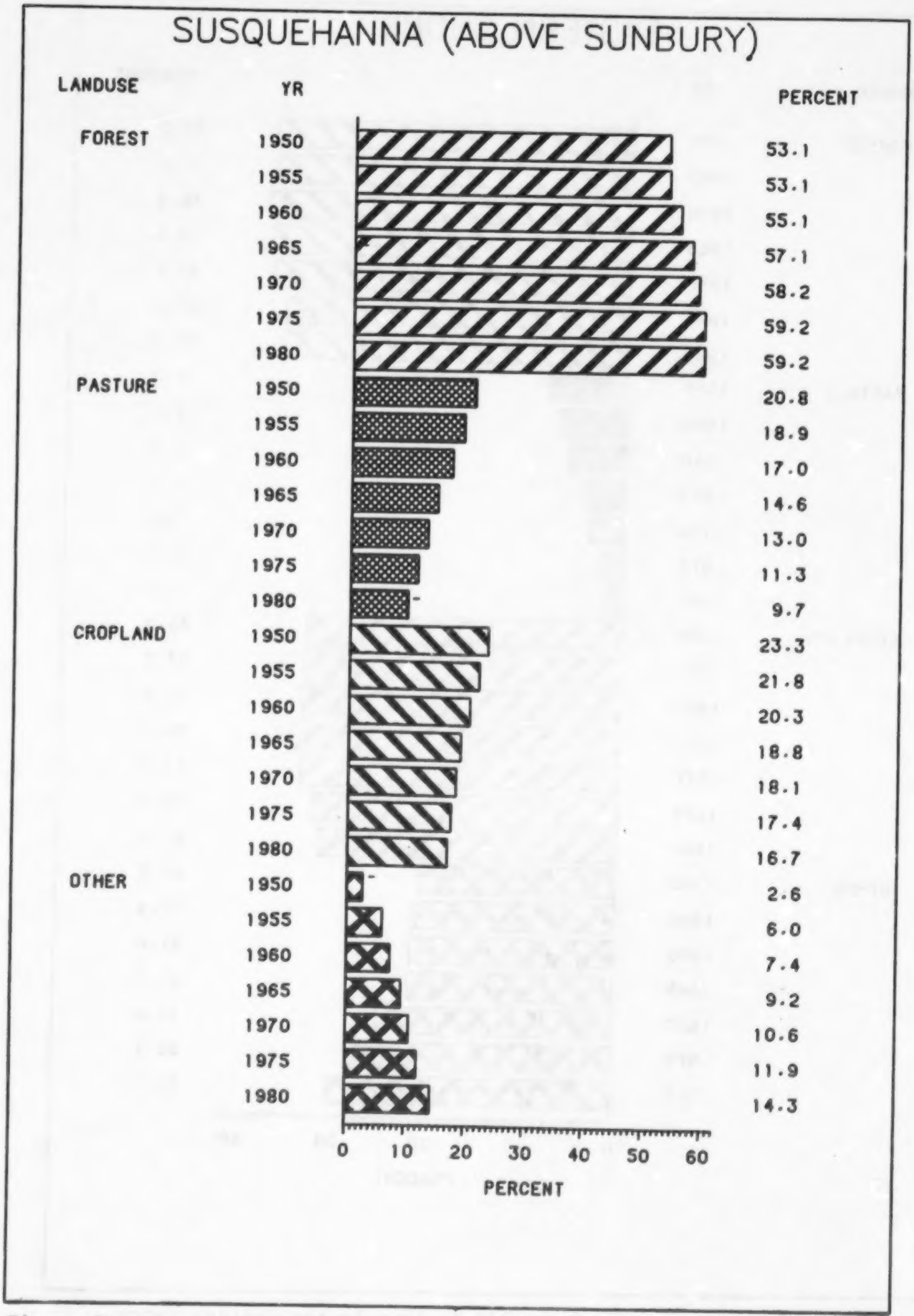


Figure 21. Land-use trends from 1950 to 1980 in the Susquehanna basin (above Sunbury)

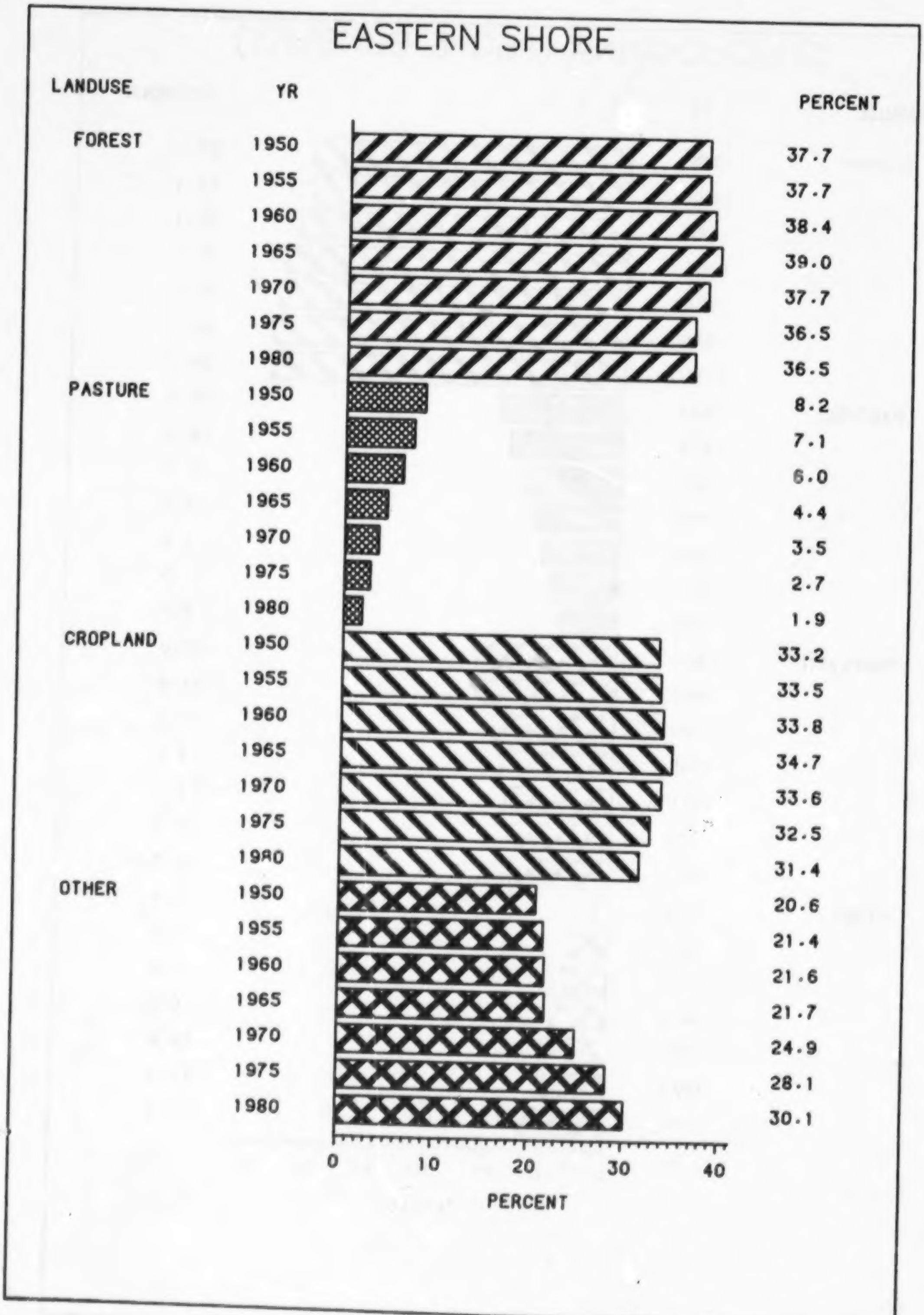


Figure 22. Land-use trends from 1950 to 1980 in the Eastern Shore basin

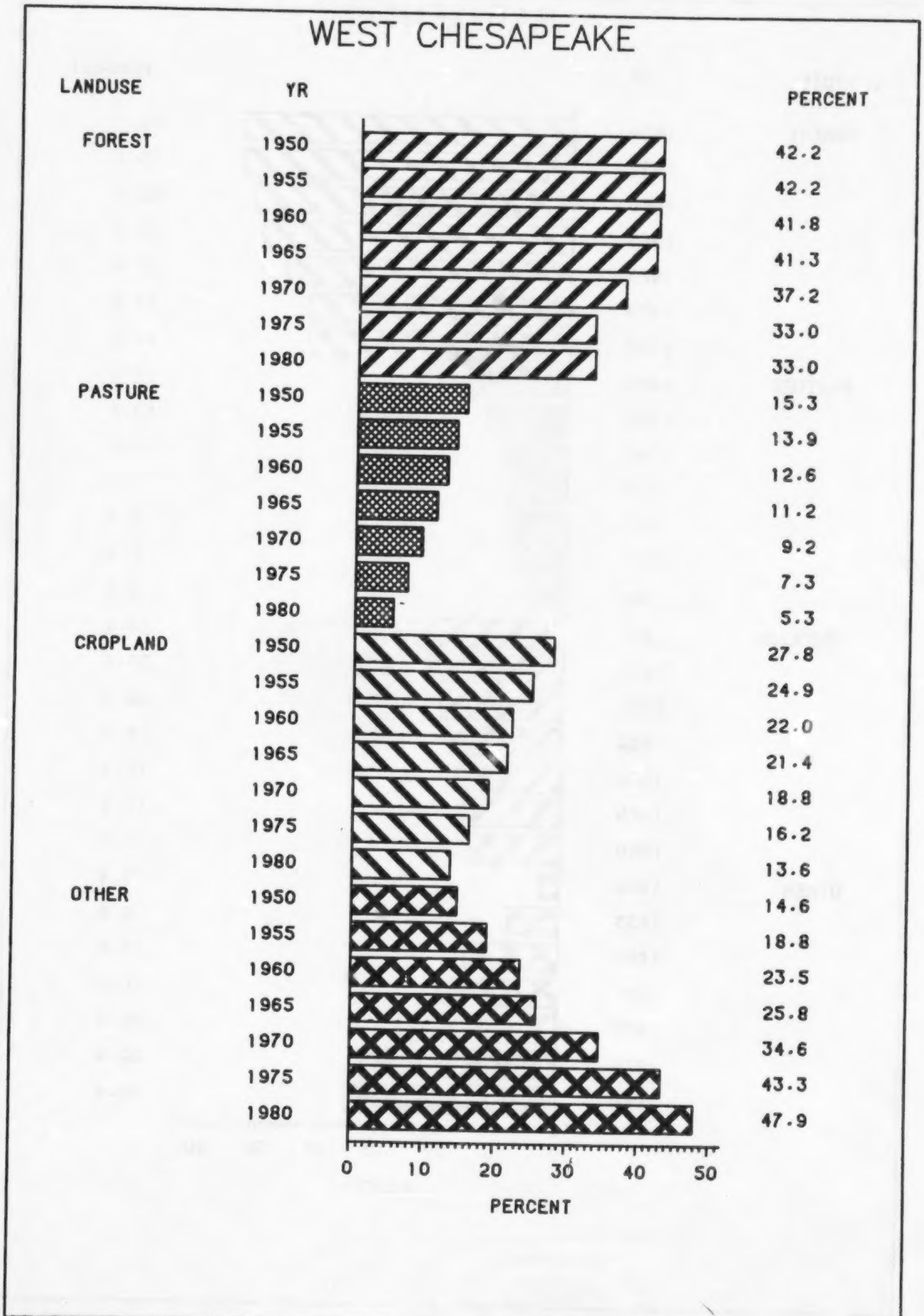


Figure 23. Land-use trends from 1950 to 1980 in the West Chesapeake basin

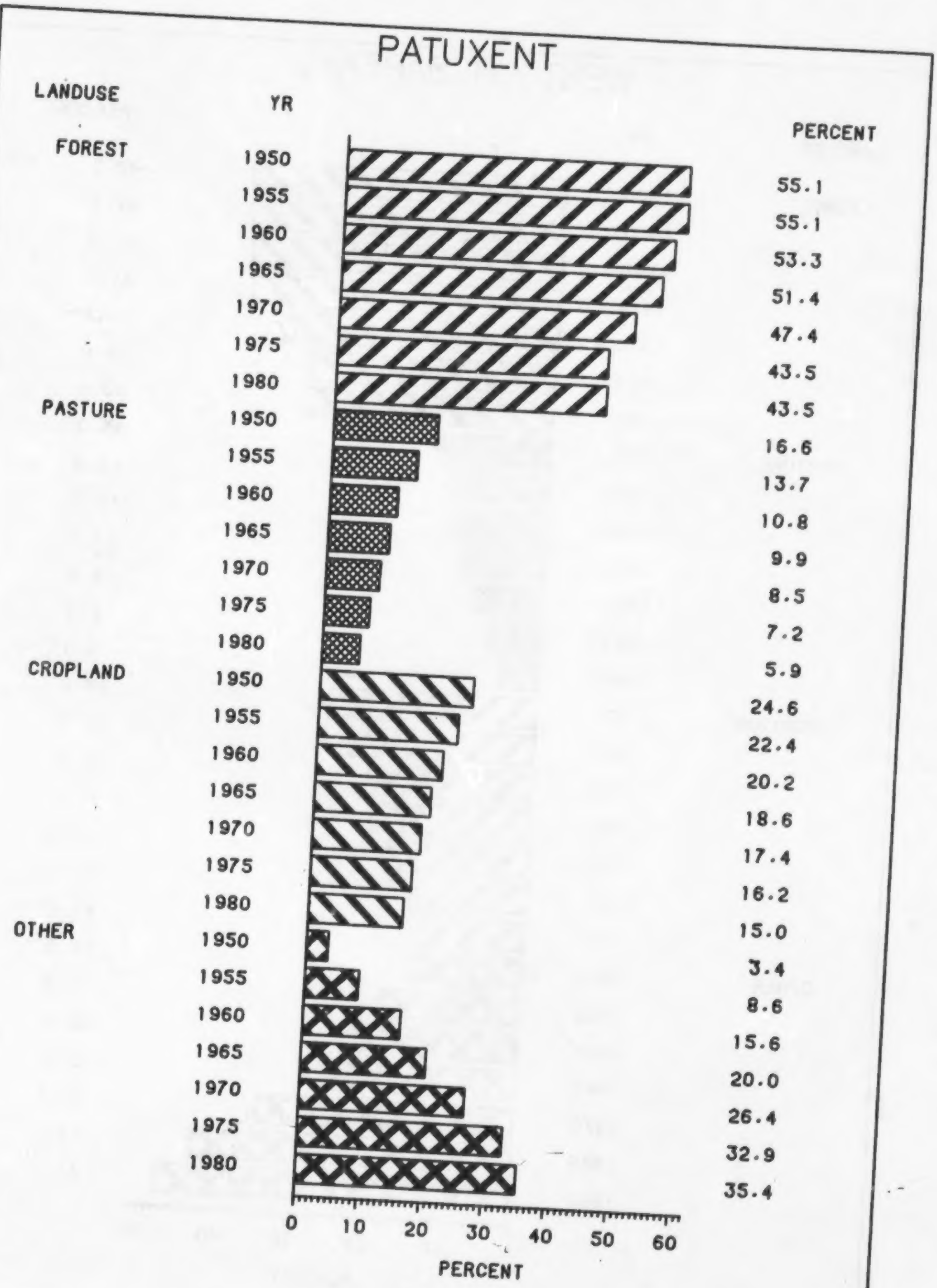


Figure 24. Land-use trends from 1950 to 1980 in the Patuxent basin

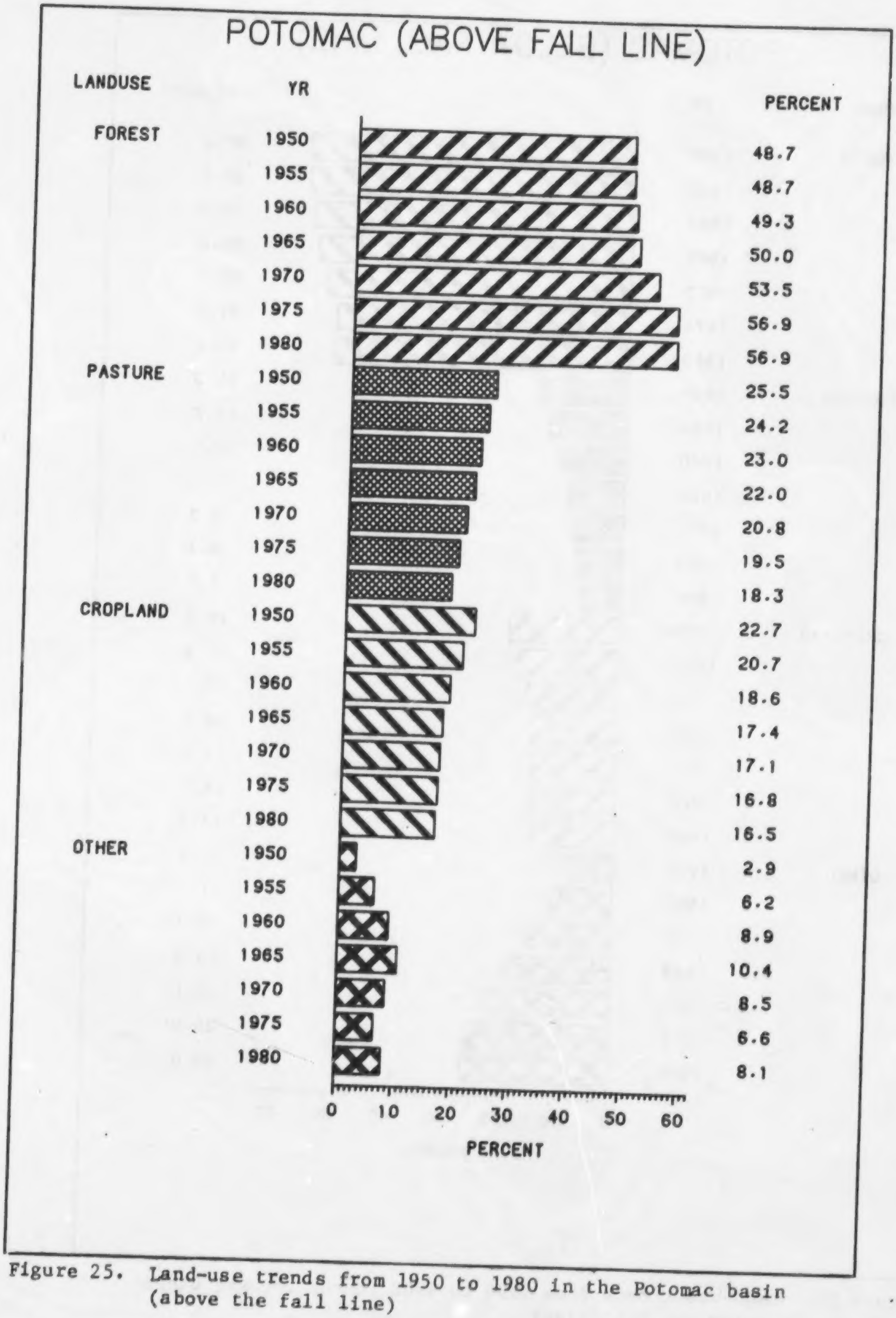


Figure 25. Land-use trends from 1950 to 1980 in the Potomac basin (above the fall line)

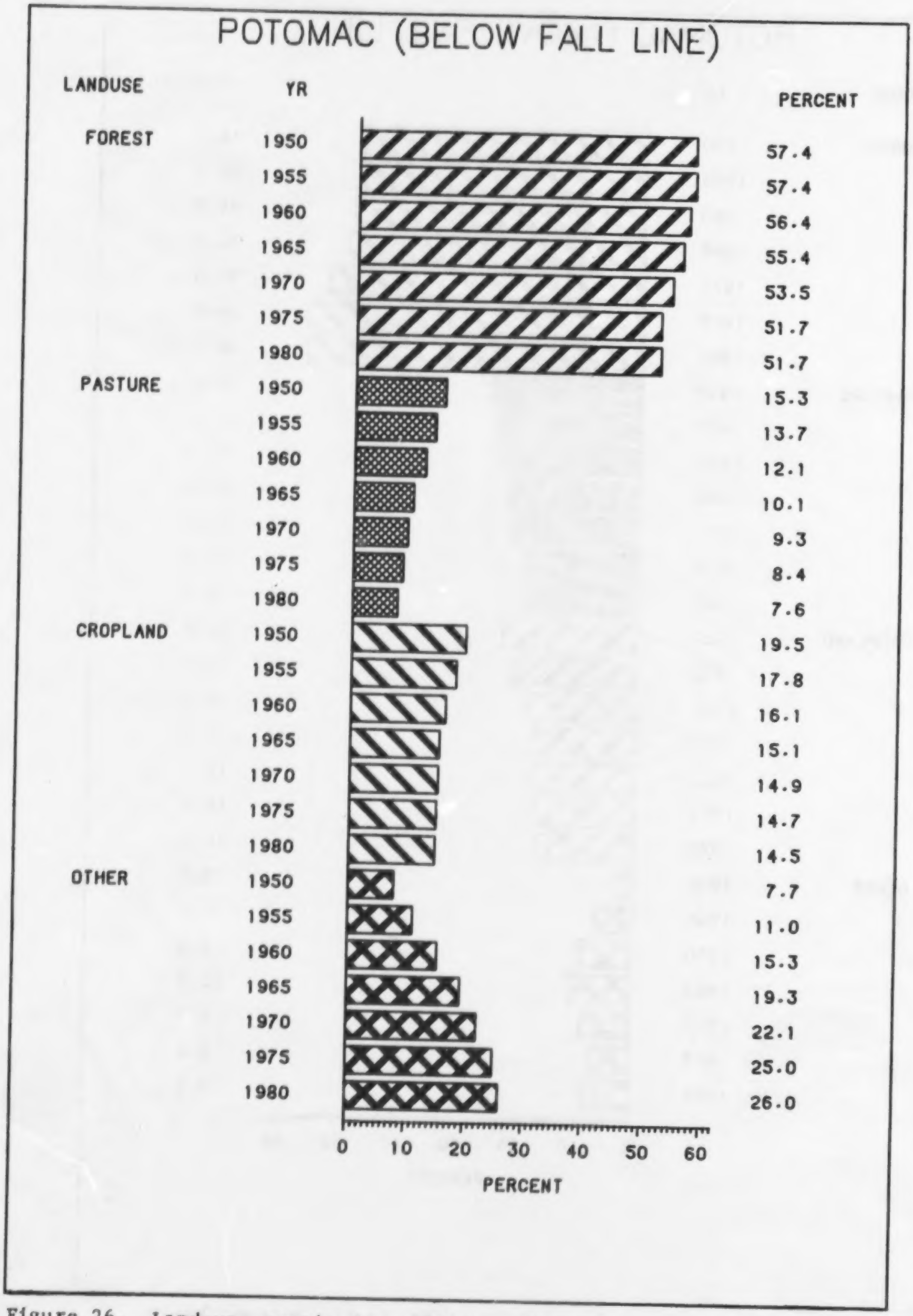


Figure 26. Land-use trends from 1950 to 1980 in the Potomac basin (below the fall line)

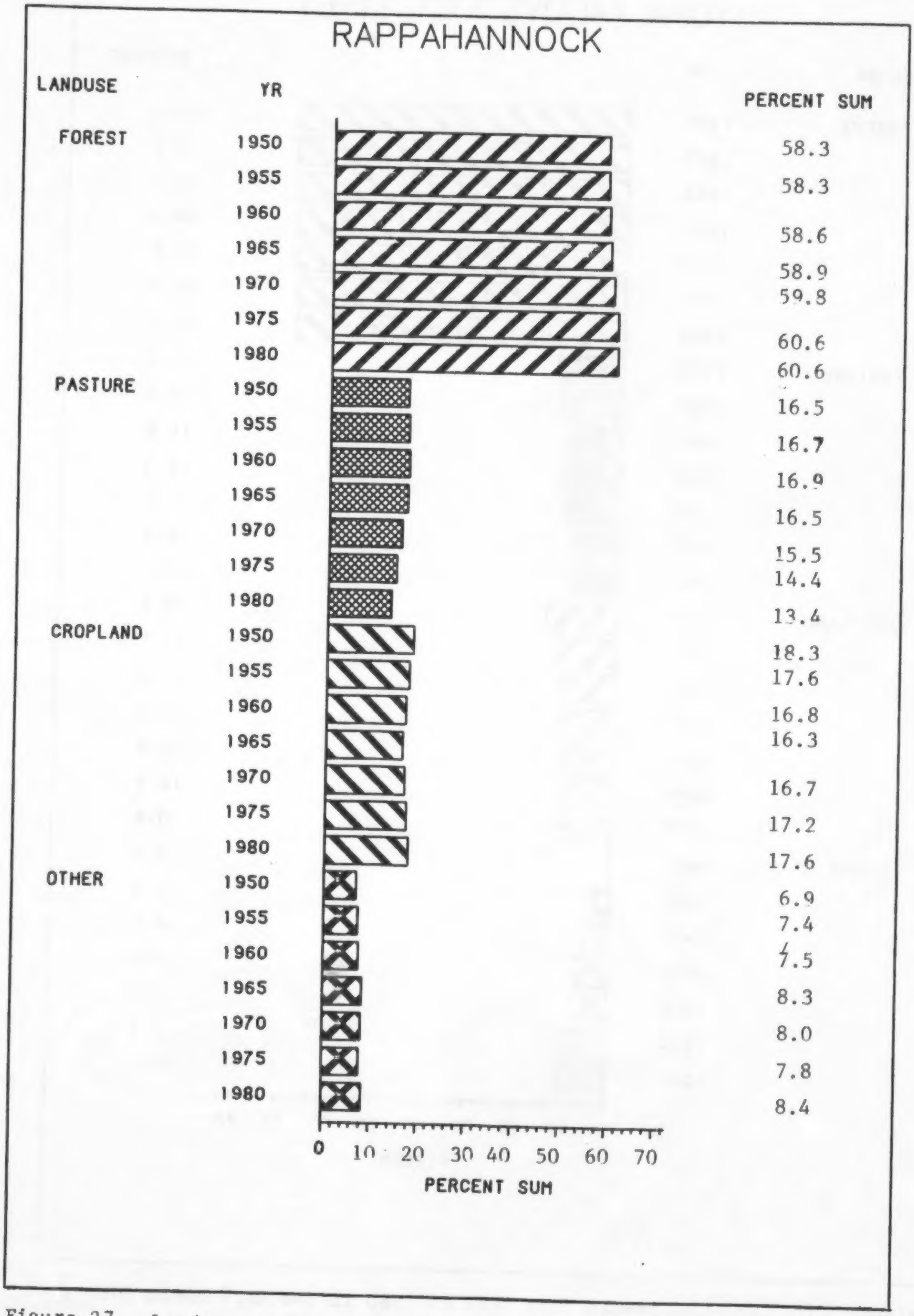


Figure 27. Land-use trends from 1950 to 1980 in the Rappahannock basin

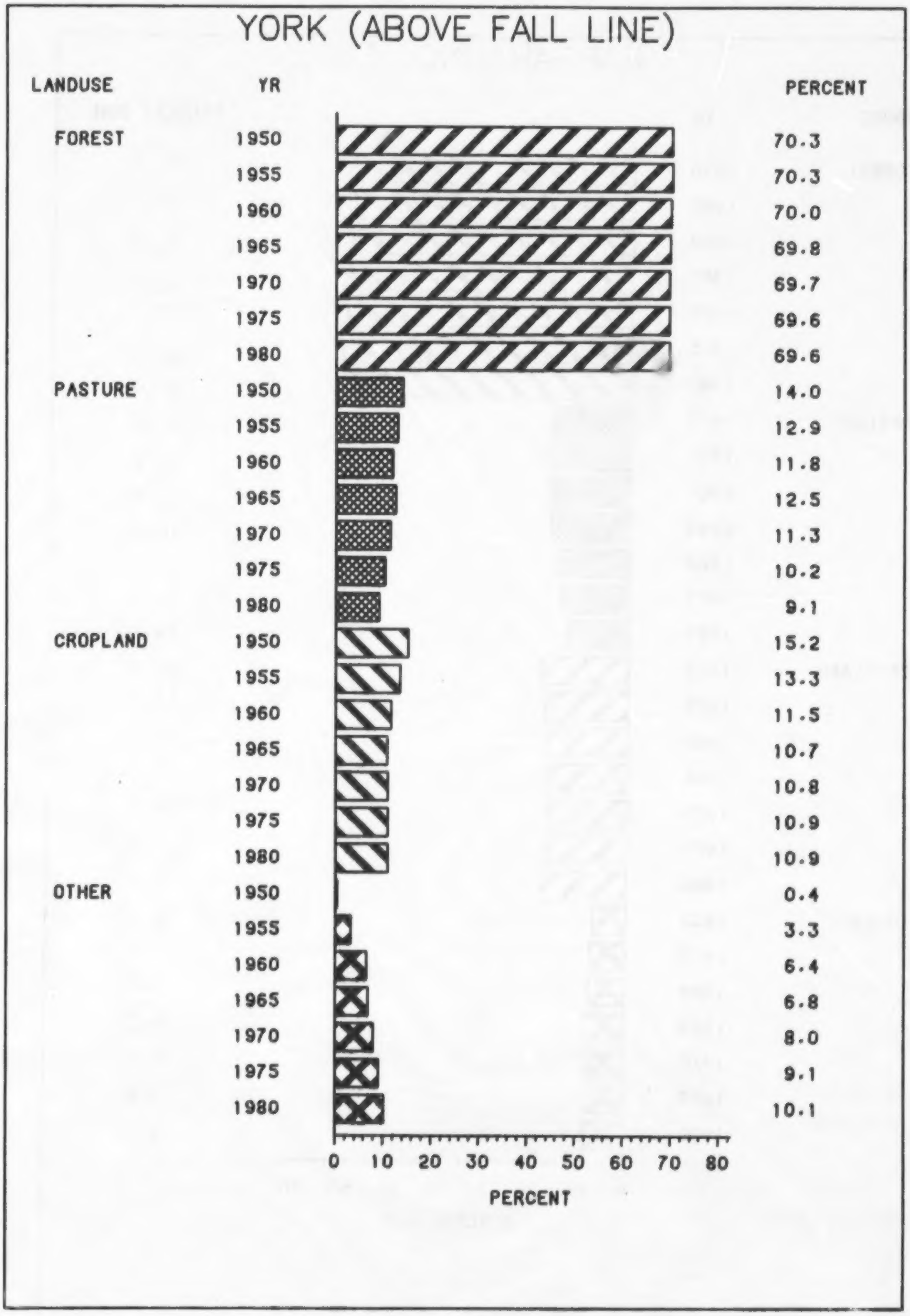


Figure 28. Land-use trends from 1950 to 1980 in the York basin (above the fall line)

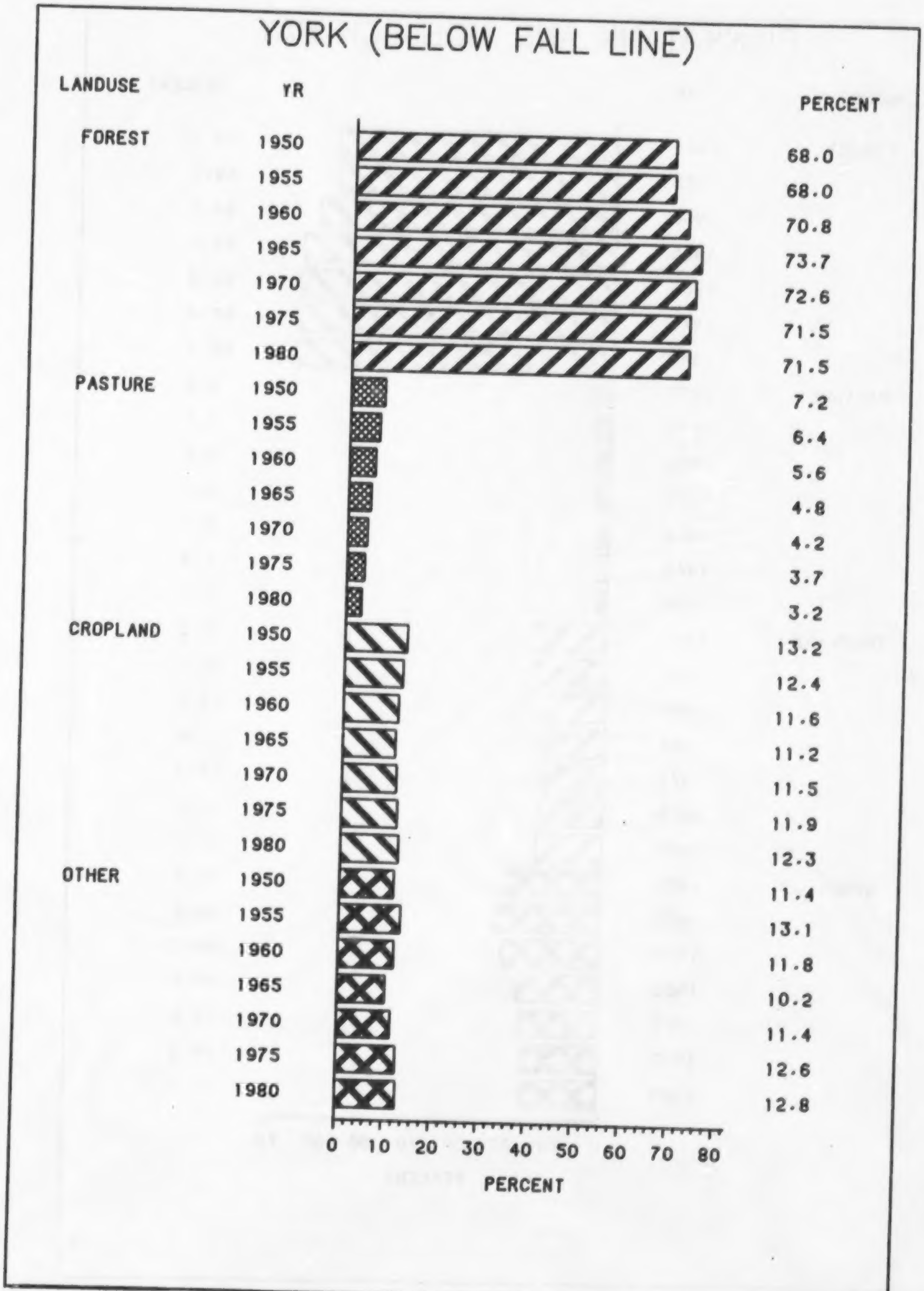


Figure 29. Land-use trends from 1950 to 1980 in the York basin (below the fall line)

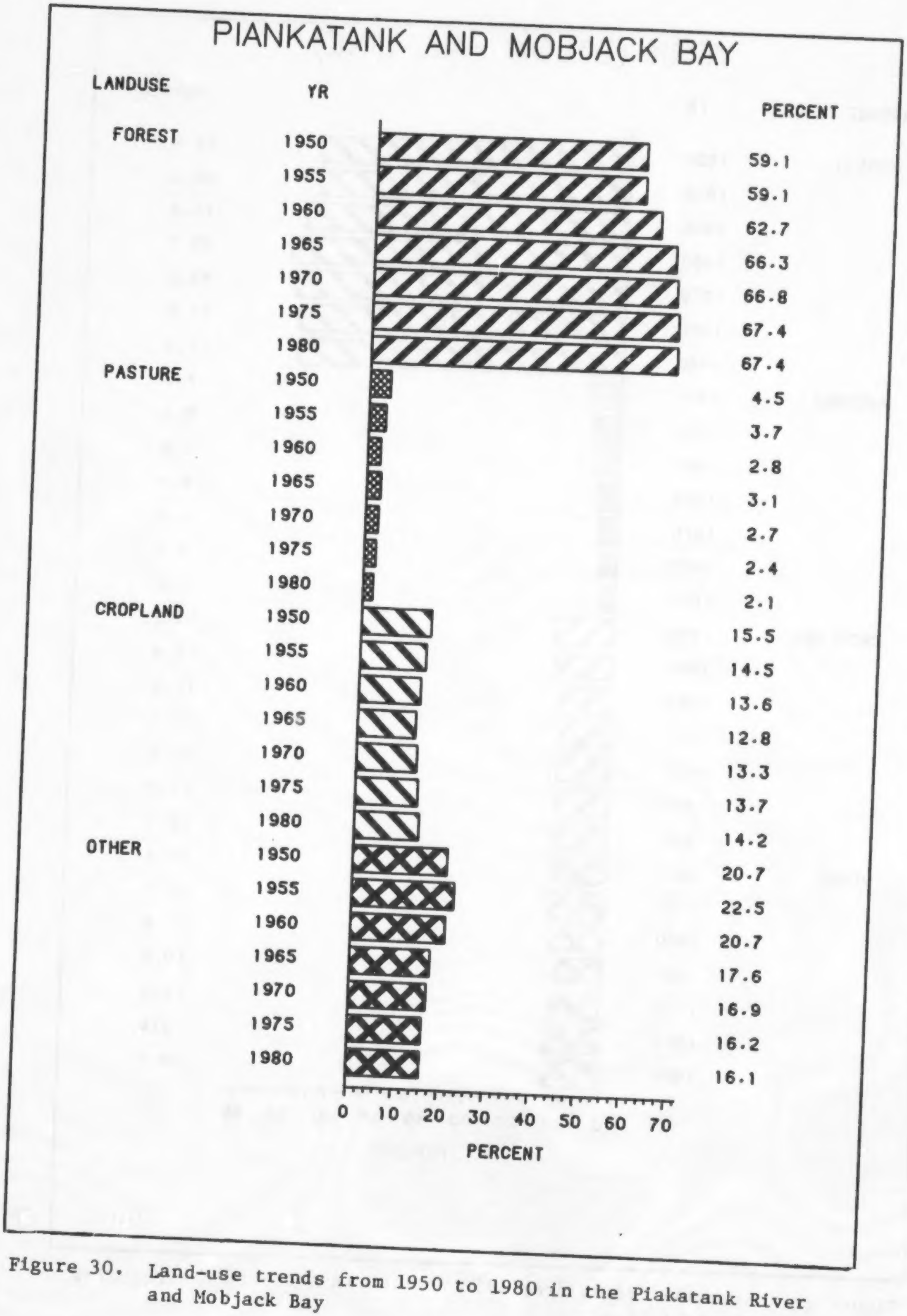


Figure 30. Land-use trends from 1950 to 1980 in the Piakatank River and Mobjack Bay

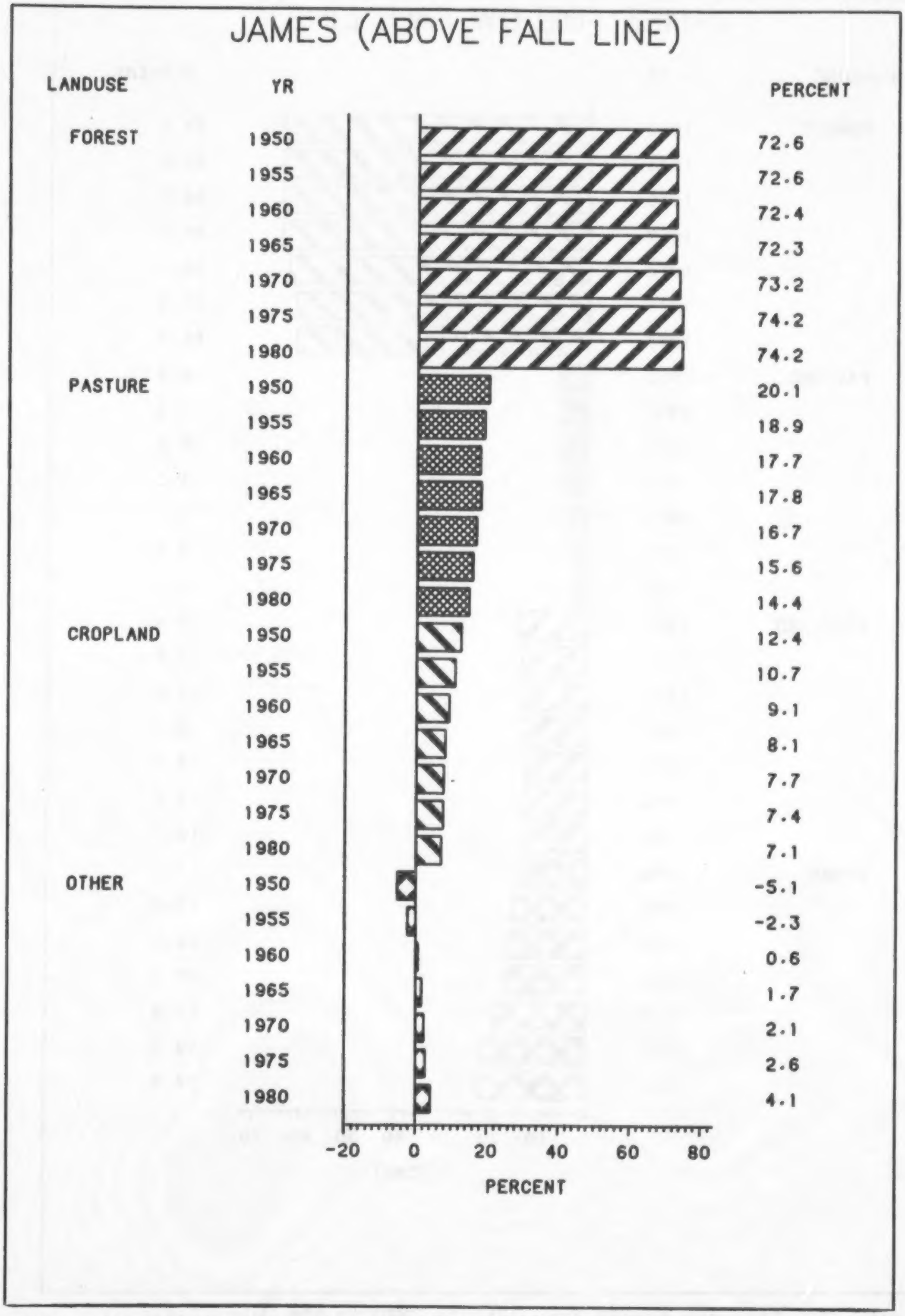


Figure 31. Land-use trends from 1950 to 1980 in the James basin (above the fall line)

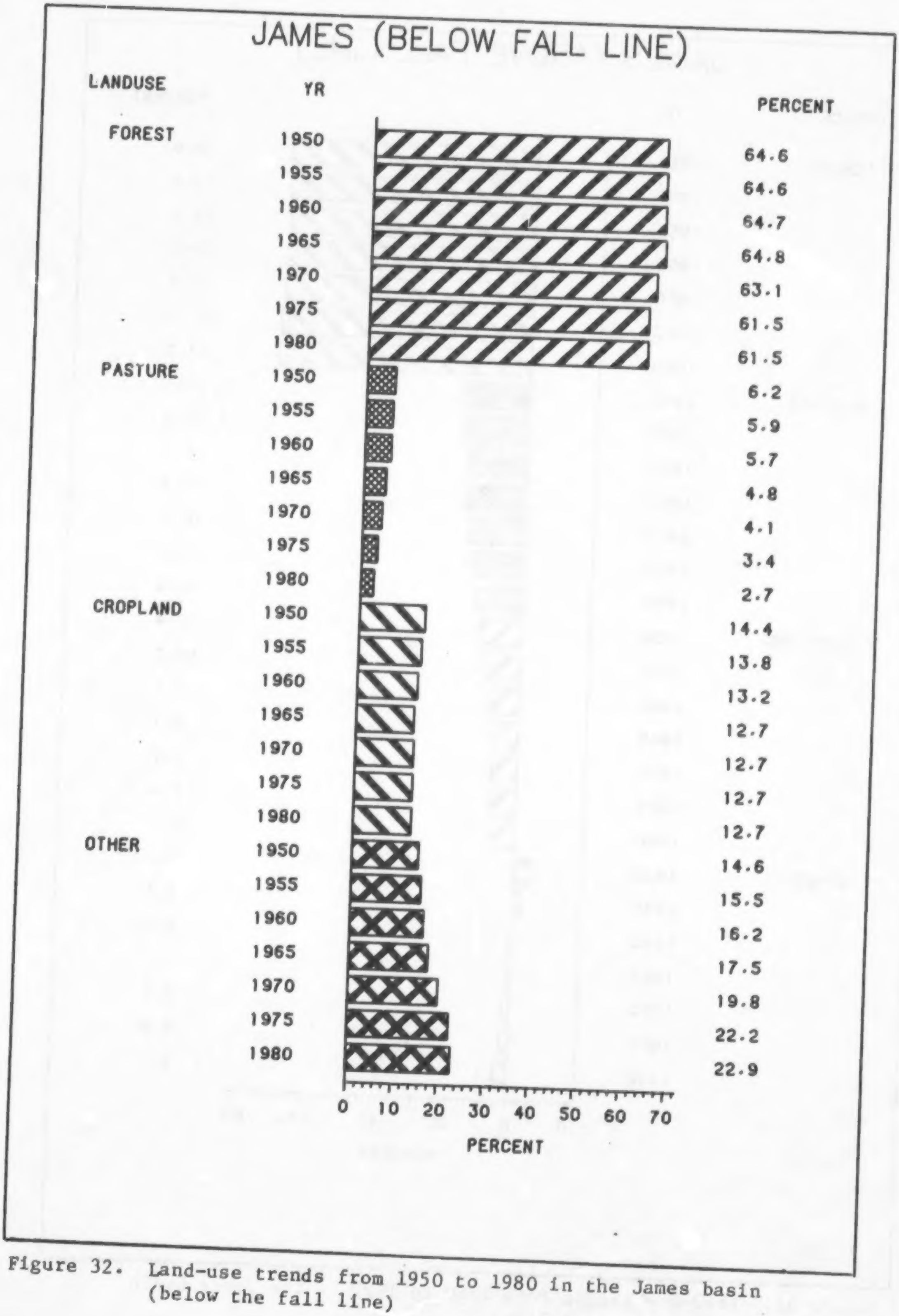


Figure 32. Land-use trends from 1950 to 1980 in the James basin (below the fall line)

TABLE 7. ESTIMATED LAND-USE IN THE CHESAPEAKE BAY BASIN, 1950 TO 1980 (EXCLUDING NEW YORK DRAINAGE AREA)

| | Total Acres in Area | Land Use* | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| C.B. Basin Above the Fall line | 27,600,000 | C | 21.1 | 19.5 | 17.9 | 16.7 | 16.2 | 15.8 | 15.4 |
| | | P | 17.5 | 16.7 | 15.7 | 14.9 | 13.8 | 12.8 | 11.8 |
| | | F | 59.0 | 59.0 | 60.5 | 62.1 | 62.5 | 62.8 | 62.8 |
| | | O | 2.4 | 4.8 | 5.9 | 6.3 | 7.5 | 8.6 | 10.0 |
| C.B. Basin Below the Fall line | 8,960,000 | C | 23.6 | 22.7 | 21.7 | 21.4 | 20.9 | 20.4 | 19.8 |
| | | P | 10.6 | 9.4 | 8.1 | 6.8 | 5.8 | 4.9 | 4.0 |
| | | F | 52.5 | 52.5 | 52.4 | 52.3 | 50.5 | 48.8 | 48.8 |
| | | O | 13.3 | 15.4 | 17.8 | 19.5 | 22.8 | 25.9 | 27.4 |
| Entire C.B. Basin | 36,560,000 | C | 21.7 | 20.3 | 18.8 | 17.9 | 17.4 | 17.0 | 16.5 |
| | | P | 15.8 | 14.8 | 13.8 | 12.9 | 11.8 | 10.7 | 9.7 |
| | | F | 57.4 | 57.4 | 58.5 | 59.6 | 59.5 | 59.4 | 59.4 |
| | | O | 5.1 | 7.5 | 8.9 | 9.6 | 11.3 | 12.9 | 14.4 |

*C = Cropland, P = Pasture, F = Forest, O = Other Lands

TABLE 8. ESTIMATED LAND USE IN MAJOR SUB-BASINS OF THE CHESAPEAKE BAY BASIN, 1950 TO 1980.

| Basin | Estimated Acreage | Land Use* | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| Susquehanna** | | | | | | | | | |
| | 13,370,000 | C | 24.1 | 22.8 | 21.4 | 20.1 | 19.43 | 18.77 | 18.1 |
| | | P | 12.0 | 11.0 | 10.0 | 9.0 | 8.13 | 7.27 | 6.4 |
| | | F | 56.6 | 57.4 | 60.2 | 62.9 | 62.4 | 61.8 | 61.3 |
| | | O | 9.3 | 8.8 | 8.4 | 8.0 | 10.0 | 12.2 | 14.2 |
| West Chesapeake | | | | | | | | | |
| | 1,025,000 | C | 27.8 | 24.9 | 22.0 | 21.5 | 18.9 | 16.3 | 13.7 |
| | | P | 15.3 | 14.0 | 12.7 | 11.3 | 9.3 | 7.3 | 5.4 |
| | | F | 42.2 | 42.2 | 41.8 | 41.4 | 37.2 | 33.1 | 33.1 |
| | | O | 14.7 | 18.9 | 23.5 | 25.9 | 34.6 | 43.3 | 47.9 |
| Eastern Shore | | | | | | | | | |
| | 2,725,000 | C | 33.3 | 33.5 | 33.8 | 34.8 | 33.7 | 32.5 | 31.4 |
| | | P | 8.3 | 7.2 | 6.1 | 4.4 | 3.6 | 2.8 | 1.9 |
| | | F | 37.8 | 37.8 | 38.4 | 39.1 | 37.8 | 36.5 | 36.5 |
| | | O | 20.7 | 21.5 | 21.7 | 21.7 | 24.9 | 28.2 | 30.1 |
| Patuxent | | | | | | | | | |
| | 603,000 | C | 24.7 | 22.5 | 20.2 | 18.6 | 17.4 | 16.3 | 15.1 |
| | | P | 16.7 | 13.8 | 10.8 | 9.9 | 8.6 | 7.3 | 6.0 |
| | | F | 55.2 | 55.2 | 53.3 | 51.4 | 47.5 | 43.5 | 43.5 |
| | | O | 3.4 | 8.6 | 15.6 | 20.0 | 26.5 | 32.9 | 35.4 |
| Potomac | | | | | | | | | |
| | 9,027,000 | C | 22.1 | 20.2 | 18.2 | 17.0 | 16.7 | 16.4 | 16.1 |
| | | P | 23.3 | 22.5 | 20.8 | 19.7 | 18.5 | 17.4 | 16.2 |
| | | F | 54.6 | 51.0 | 44.8 | 38.6 | 47.3 | 56.0 | 64.7 |
| | | O | 7.2 | 8.8 | 8.4 | 8.0 | 10.0 | 12.2 | 14.2 |
| Rappahannock | | | | | | | | | |
| | 1,620,000 | C | 18.5 | 17.7 | 16.8 | 16.1 | 16.4 | 16.7 | 17.0 |
| | | P | 18.9 | 19.6 | 20.3 | 19.7 | 18.6 | 17.4 | 16.3 |
| | | F | 56.0 | 57.1 | 58.2 | 57.4 | 58.2 | 59.0 | 59.8 |
| | | O | 6.6 | 5.6 | 4.7 | 6.8 | 6.8 | 6.9 | 6.9 |
| York-Piankatank | | | | | | | | | |
| | 1,950,000 | C | 14.4 | 13.2 | 11.9 | 11.3 | 11.5 | 11.8 | 12.0 |
| | | P | 9.9 | 9.0 | 8.0 | 8.0 | 7.2 | 6.5 | 5.7 |
| | | F | 66.4 | 67.6 | 68.8 | 70.0 | 70.0 | 70.1 | 70.1 |
| | | O | 9.3 | 10.2 | 11.3 | 10.7 | 11.3 | 11.6 | 12.2 |
| James | | | | | | | | | |
| | 6,324,000 | C | 12.8 | 11.4 | 9.9 | 9.0 | 8.7 | 8.5 | 8.2 |
| | | P | 17.6 | 16.6 | 15.5 | 15.5 | 14.4 | 13.4 | 12.3 |
| | | F | 71.0 | 71.1 | 71.3 | 71.4 | 71.6 | 71.8 | 72.0 |
| | | O | 1.0 | 1.0 | 3.3 | 4.1 | 5.3 | 6.3 | 7.5 |

* C = Cropland, P = Pasture, F = Forest, O = Other Lands

**New York's Susquehanna drainage area not included.

TABLE 9. ESTIMATED LAND USE IN MINOR SUB-BASINS OF THE CHESAPEAKE BAY BASIN, 1950-1980

| Basin | Estimated Acreage | Land Use* | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| Susquehanna | | | | | | | | | |
| Above Sunbury (excluding New York drainage) | 3,090,260 | C | 23.4 | 21.9 | 20.3 | 18.8 | 18.1 | 17.4 | 16.7 |
| | | P | 20.8 | 18.9 | 17.1 | 14.7 | 13.0 | 11.4 | 9.7 |
| | | F | 53.2 | 53.2 | 55.2 | 57.2 | 58.2 | 59.3 | 59.3 |
| | | O | 2.6 | 6.0 | 7.4 | 9.3 | 10.6 | 12.0 | 14.3 |
| West Branch | 4,533,000 | C | 12.7 | 11.7 | 10.7 | 9.8 | 9.4 | 9.0 | 8.7 |
| | | P | 7.2 | 6.3 | 5.4 | 4.7 | 4.2 | 3.8 | 3.4 |
| | | F | 74.3 | 74.3 | 78.6 | 83.0 | 81.3 | 79.6 | 79.6 |
| | | O | 5.8 | 7.7 | 5.3 | 2.6 | 5.1 | 7.6 | 8.4 |
| Juniata | 2,157,000 | C | 21.4 | 20.0 | 18.6 | 17.1 | 16.5 | 15.8 | 15.1 |
| | | P | 11.3 | 10.5 | 9.7 | 9.1 | 8.3 | 7.6 | 6.8 |
| | | F | 62.6 | 62.6 | 65.2 | 67.9 | 67.9 | 67.9 | 67.9 |
| | | O | 4.8 | 6.9 | 6.4 | 5.8 | 7.3 | 8.7 | 10.1 |
| Sunbury to Harrisburg | 1,527,000 | C | 33.2 | 31.5 | 29.9 | 27.6 | 27.0 | 26.3 | 25.0 |
| | | P | 8.0 | 7.7 | 7.4 | 6.9 | 6.5 | 6.1 | 5.7 |
| | | F | 48.5 | 48.5 | 50.7 | 52.8 | 51.7 | 50.6 | 50.6 |
| | | O | 10.2 | 12.2 | 12.0 | 12.7 | 14.8 | 17.0 | 18.0 |
| Harrisburg to Mouth | 2,063,240 | C | 46.5 | 44.7 | 42.9 | 41.9 | 40.8 | 39.6 | 38.5 |
| | | P | 12.9 | 12.6 | 12.3 | 11.5 | 10.4 | 9.4 | 8.3 |
| | | F | 27.8 | 27.8 | 28.8 | 29.9 | 29.2 | 28.5 | 28.5 |
| | | O | 12.7 | 14.8 | 16.0 | 16.8 | 19.6 | 22.5 | 24.7 |
| West Chesapeake | 1,137,050 | C | 27.8 | 24.9 | 22.0 | 21.5 | 18.9 | 16.3 | 13.7 |
| | | P | 15.3 | 14.0 | 12.7 | 11.3 | 9.3 | 7.3 | 5.4 |
| | | F | 42.2 | 42.2 | 41.8 | 41.4 | 37.2 | 33.1 | 33.1 |
| | | O | 14.7 | 18.9 | 23.5 | 25.9 | 34.6 | 43.3 | 47.9 |
| Eastern Shore | 2,733,116 | C | 33.3 | 33.5 | 33.8 | 34.8 | 33.7 | 32.5 | 31.4 |
| | | P | 8.3 | 7.2 | 6.1 | 4.4 | 3.6 | 2.8 | 1.9 |
| | | F | 37.8 | 37.8 | 38.4 | 39.1 | 37.8 | 36.5 | 36.5 |
| | | O | 20.7 | 21.5 | 21.7 | 21.7 | 24.9 | 28.2 | 30.1 |
| Patuxent | 603,870 | C | 24.7 | 22.5 | 20.2 | 18.6 | 17.4 | 16.3 | 15.1 |
| | | P | 16.7 | 13.8 | 10.8 | 9.9 | 8.6 | 7.3 | 6.0 |
| | | F | 55.2 | 55.2 | 53.3 | 51.4 | 47.5 | 43.5 | 43.5 |
| | | O | 3.4 | 8.6 | 15.6 | 20.0 | 26.5 | 32.9 | 35.4 |

(continued)

TABLE 9. (continued)

| Basin 1980 | Estimated Acreage | Land Use* | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | |
|---|---|---|---|---|---|---|---|---|---|
| **Potomac** | | | | | | | | | |
| Above fall line | 6,714,300 | C | 22.8 | 20.7 | 18.7 | 17.4 | 17.1 | 16.8 | 16.5 |
| | | P | 25.5 | 24.3 | 23.0 | 22.1 | 20.8 | 19.6 | 18.3 |
| | | F | 48.7 | 48.7 | 49.4 | 50.0 | 53.5 | 57.0 | 57.0 |
| | | O | 3.0 | 6.3 | 8.9 | 10.5 | 8.6 | 6.6 | 8.2 |
| Below fall line | 1,799,400 | C | 19.5 | 17.8 | 16.1 | 15.1 | 14.9 | 14.7 | 14.6 |
| | | P | 15.4 | 13.8 | 12.1 | 10.1 | 9.3 | 8.5 | 7.6 |
| | | F | 57.4 | 57.4 | 56.4 | 55.4 | 53.6 | 51.7 | 51.7 |
| | | O | 7.7 | 11.0 | 15.3 | 19.3 | 22.2 | 25.0 | 26.1 |
| **Rappahannock** | | | | | | | | | |
| Above fall line | 1,039,530 | C | 18.9 | 17.8 | 16.6 | 15.5 | 15.4 | 15.3 | 15.3 |
| | | P | 25.1 | 27.1 | 28.9 | 27.8 | 26.4 | 25.0 | 23.6 |
| | | F | 53.6 | 53.6 | 53.5 | 53.4 | 54.3 | 55.2 | 55.2 |
| | | O | 2.4 | 1.5 | 1.0 | 3.3 | 3.9 | 4.5 | 5.9 |
| Below fall line | 583,620 | C | 17.6 | 17.4 | 17.2 | 17.0 | 18.0 | 19.0 | 19.9 |
| | | P | 7.9 | 6.5 | 5.0 | 5.2 | 4.6 | 3.9 | 3.2 |
| | | F | 63.0 | 63.0 | 63.7 | 64.4 | 65.2 | 66.0 | 66.0 |
| | | O | 12.5 | 13.1 | 14.1 | 13.4 | 12.2 | 11.1 | 10.9 |
| **York** | | | | | | | | | |
| Above fall line | 852,000 | C | 15.2 | 13.4 | 11.6 | 10.8 | 10.9 | 10.9 | 11.0 |
| | | P | 14.0 | 12.9 | 11.9 | 12.5 | 11.4 | 10.2 | 9.1 |
| | | F | 70.3 | 70.3 | 70.1 | 69.8 | 69.8 | 69.7 | 69.7 |
| | | O | 0.5 | 3.3 | 6.5 | 6.9 | 8.0 | 9.1 | 10.2 |
| Below fall line | 796,600 | C | 13.2 | 12.4 | 11.6 | 11.2 | 11.6 | 12.0 | 12.3 |
| | | P | 7.3 | 6.5 | 5.6 | 4.8 | 4.3 | 3.8 | 3.2 |
| | | F | 68.0 | 68.0 | 70.9 | 73.8 | 72.7 | 71.6 | 71.6 |
| | | O | 11.5 | 13.1 | 11.9 | 10.2 | 11.4 | 11.6 | 12.9 |
| **Piankatank** | 280,406 | C | 15.5 | 14.6 | 13.6 | 12.9 | 13.3 | 13.8 | 14.3 |
| | | P | 4.6 | 3.7 | 2.9 | 3.1 | 2.8 | 2.5 | 2.2 |
| | | F | 59.2 | 59.2 | 62.7 | 66.4 | 66.9 | 67.4 | 67.4 |
| | | O | 20.8 | 22.6 | 20.7 | 17.7 | 17.0 | 16.3 | 16.1 |
| **James** | | | | | | | | | |
| Above fall line | 5,085,000 | C | 12.4 | 10.8 | 9.1 | 8.1 | 7.8 | 7.5 | 7.2 |
| | | P | 20.1 | 19.0 | 17.8 | 17.9 | 16.8 | 15.6 | 14.5 |
| | | F | 72.6 | 72.6 | 72.5 | 72.3 | 73.3 | 74.2 | 74.2 |
| | | O | -5.2 | -2.3 | 0.7 | 1.7 | 2.2 | 2.7 | 4.1 |
| Below fall line | 1,155,000 | C | 14.5 | 13.9 | 13.2 | 12.7 | 12.7 | 12.8 | 12.8 |
| | | P | 6.2 | 6.0 | 5.7 | 4.9 | 4.2 | 3.5 | 2.7 |
| | | F | 64.6 | 64.6 | 64.8 | 64.9 | 63.2 | 61.5 | 61.5 |
| | | O | 14.6 | 15.5 | 16.3 | 17.5 | 19.9 | 22.3 | 23.0 |

*C = Cropland, P = Pasture, F = Forest, O = Other Land

TABLE 10. ESTIMATED LAND USE IN THE CHESAPEAKE BAY BASIN, BY STATE, 1950-1980

| | Land Use* | 1950 | 1955 | 1960 | 1965 | 1970 | 1975 | 1980 |
|---|---|---|---|---|---|---|---|---|
| Maryland | C | 29.7 | 28.3 | 26.9 | 26.5 | 25.6 | 24.8 | 24.0 |
| | P | 15.1 | 13.7 | 12.2 | 10.6 | 9.2 | 7.8 | 6.4 |
| | F | 45.2 | 45.2 | 45.5 | 45.7 | 43.0 | 40.3 | 40.3 |
| | O | 10.0 | 12.8 | 15.4 | 17.2 | 22.2 | 27.1 | 29.3 |
| Pennsylvania | C | 24.7 | 23.3 | 21.9 | 20.6 | 20.0 | 19.3 | 18.7 |
| | P | 12.0 | 11.1 | 10.2 | 9.2 | 8.3 | 7.5 | 6.6 |
| | F | 57.0 | 57.0 | 59.6 | 62.2 | 61.8 | 61.3 | 61.3 |
| | O | 8.3 | 8.6 | 8.3 | 8.0 | 9.9 | 11.9 | 13.4 |
| Virginia | C | 15.7 | 14.3 | 13.0 | 12.1 | 12.1 | 12.0 | 12.0 |
| | P | 18.6 | 17.6 | 16.5 | 16.1 | 15.3 | 14.4 | 13.6 |
| | F | 62.8 | 62.8 | 63.2 | 63.5 | 63.8 | 64.1 | 64.1 |
| | O | 3.9 | 5.3 | 7.3 | 8.3 | 8.8 | 9.5 | 10.3 |
| District of Columbia | C | 0.9 | .5 | 0 | 0 | 0 | 0 | 0 |
| | P | 0.5 | .3 | 0 | 0 | 0 | 0 | 0 |
| | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | O | 98.6 | 99.2 | 100 | 100 | 100 | 100 | 100 |
| Delaware | C | 36.6 | 37.1 | 37.6 | 38.6 | 38.9 | 39.2 | 39.4 |
| | P | 6.4 | 5.3 | 4.1 | 3.5 | – | – | – |
| | F | – | – | – | 35.8 | 35.8 | 35.8 | 35.8 |
| | O | – | – | – | 22.1 | – | – | – |
| West Virginia | C | 14.1 | 12.3 | 10.4 | 9.4 | 9.1 | 8.7 | 8.4 |
| | P | 28.2 | 27.3 | 26.4 | 25.2 | 23.2 | 21.3 | 19.3 |
| | F | – | – | – | – | – | 73.4 | 73.4 |
| | O | – | – | – | – | – | -3.4 | -1.1 |
| New York[1] | C | | | | | | | 20.5 |
| | P | | | | | | | 5.9 |
| | F | | | | | | | 60.5 |
| | O | | | | | | | 13.1 |

[1] New York is not included in historical analyses; 1980 data based upon New York
State LUNR inventory in Chemung and Susquehanna 303(e) River Basin Plans, New York Department of Environmental Conservation.

*C = Cropland, P = Pasture, F = Forest, O = Other Land

TABLE 11. CHESAPEAKE BAY BASIN LAND AREA, BY STATE

| State | Total Acres | Acres in Basin | % State in Basin | % Basin in State |
|---|---|---|---|---|
| Delaware | 1,265,920 | 442,000 | 34.9 | 1.1 |
| District of Columbia | 39,040 | 39,000 | 100.0 | 0.1 |
| Maryland | 6,138,880 | 5,931,000 | 96.6 | 14.6 |
| New York | 31,728,640 | 3,991,000 | 12.6 | 9.8 |
| Pennsylvania | 28,828,800 | 14,177,000 | 49.2 | 34.9 |
| Virginia | 25,535,360 | 13,758,000 | 53.9 | 33.9 |
| West Virginia | 15,374,000 | 2,231,000 | 14.5 | 5.5 |
| TOTAL | | 40,569,000* | | 99.9 |

* = 63,390 sq. miles

## Methodology for Determining Present (1980) Land Use

The CBP set up a basin-wide computer model to estimate nutrient loadings from nonpoint sources. Because nonpoint source loadings are dependent on land cover and land-use, the CBP funded a study to estimate, by sub-basin the acreage for approximately ten land-cover categories using LANDSAT imagery (USGS Level I Land Cover Classification). The land cover analysis was performed on the Eastern Regional Remote Sensing Application Center (ERRSAC) Hewlett-Packard 3000 computer at Goddard Space Center. The land-cover data set was developed using the Interactive Digital Image Manipulation System (IDIMS) and Geographic Entry System (GES) software packages.

The land-use categories identified were: forest, cropland with winter cover ("low-till"), cropland without winter cover ("high-till"), pasture, low-density (large lot) residential, medium density residential, high-density (townhouse/garden apartment) residential, commercial-industrial, and idle land (Figure 33 illustrates the aerial coverage of LANDSAT scenes.). LANDSAT scenes used in the analysis were photographed between 1977 and 1979 (April, May, and June were analyzed to differentiate between minimum and conventional-tillage cropland) and are assumed to represent 1980 land-use patterns. Ground truthing of the LANDSAT data against other land-use data sets and field surveys suggest that the data on land cover, including tillage practices, were reliable. A detailed account of the LANDSAT analysis is described in the Chesapeake Bay Model Final Report (Hartigan 1983).

The data were aggregated into sub-basin units (or "reaches") for use in the basin model. Figure 34 and 35 illustrate the location of individual sub-basins. Reaches can be grouped to correspond with the 17 minor sub-basins used for the historical population and land-use trends analysis. Table 12 tabulates present basin land-use acreage by reach (above the fall line) and coastal sub-basin (below the fall line). Table 13 sums the figures in Table 12 to the major sub-basin level. Table 14 is an example of how to aggregate sub-basins to represent the minor sub-basin; data are presented elsewhere in the Appendices.

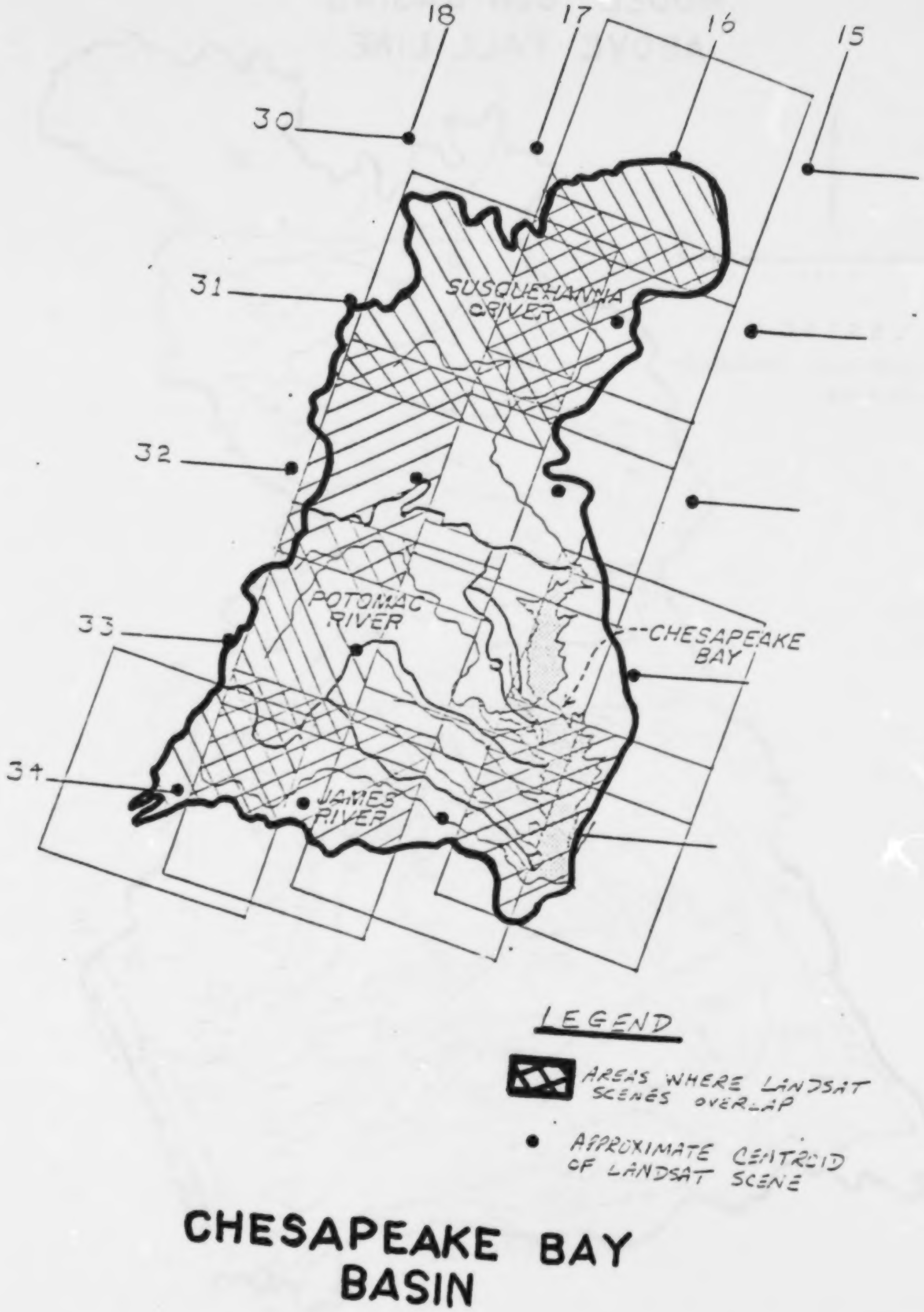


Figure 33. LANDSAT scenes used for land-use analysis

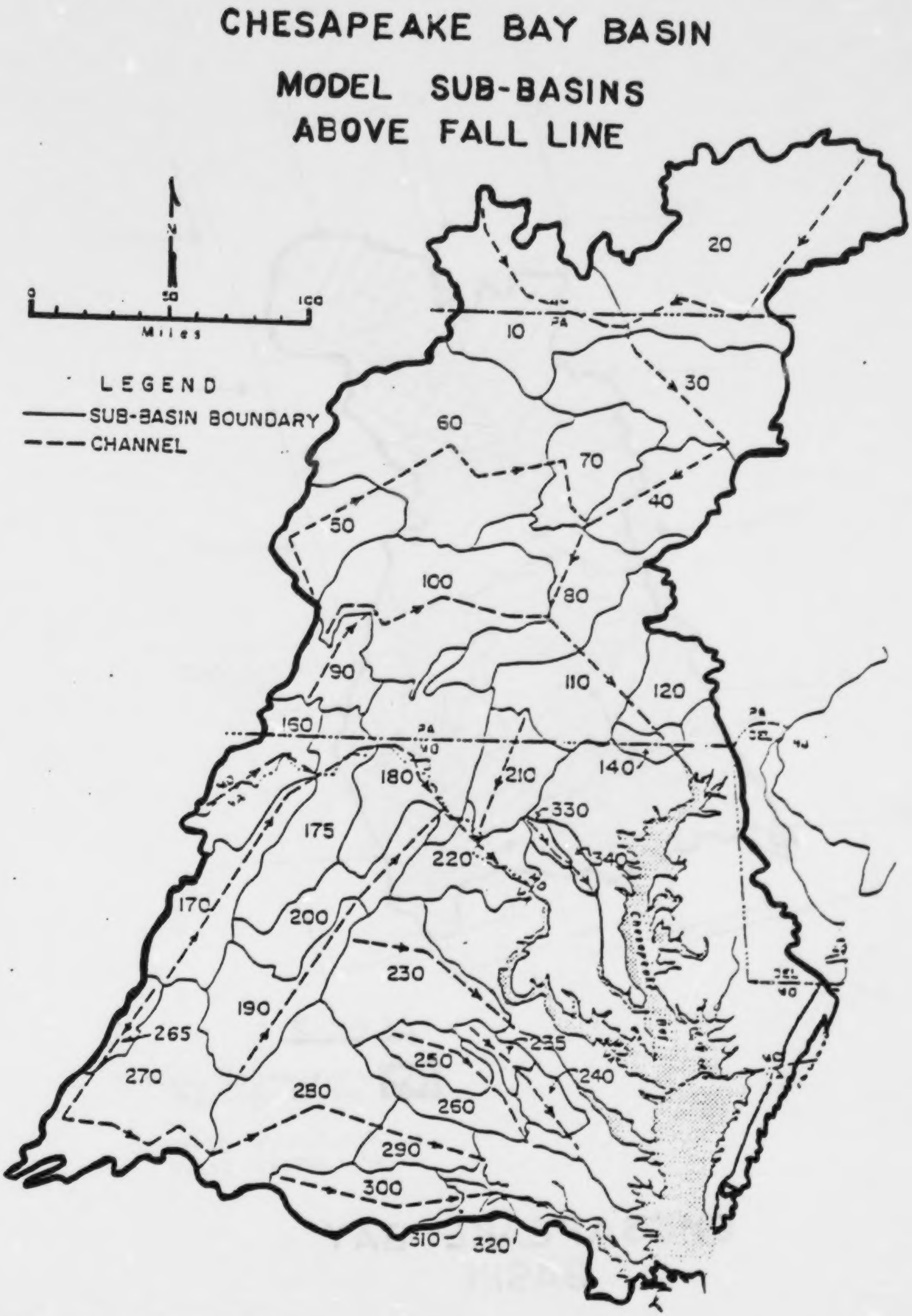


Figure 34. Chesapeake Bay basin model sub-basins above the fall line

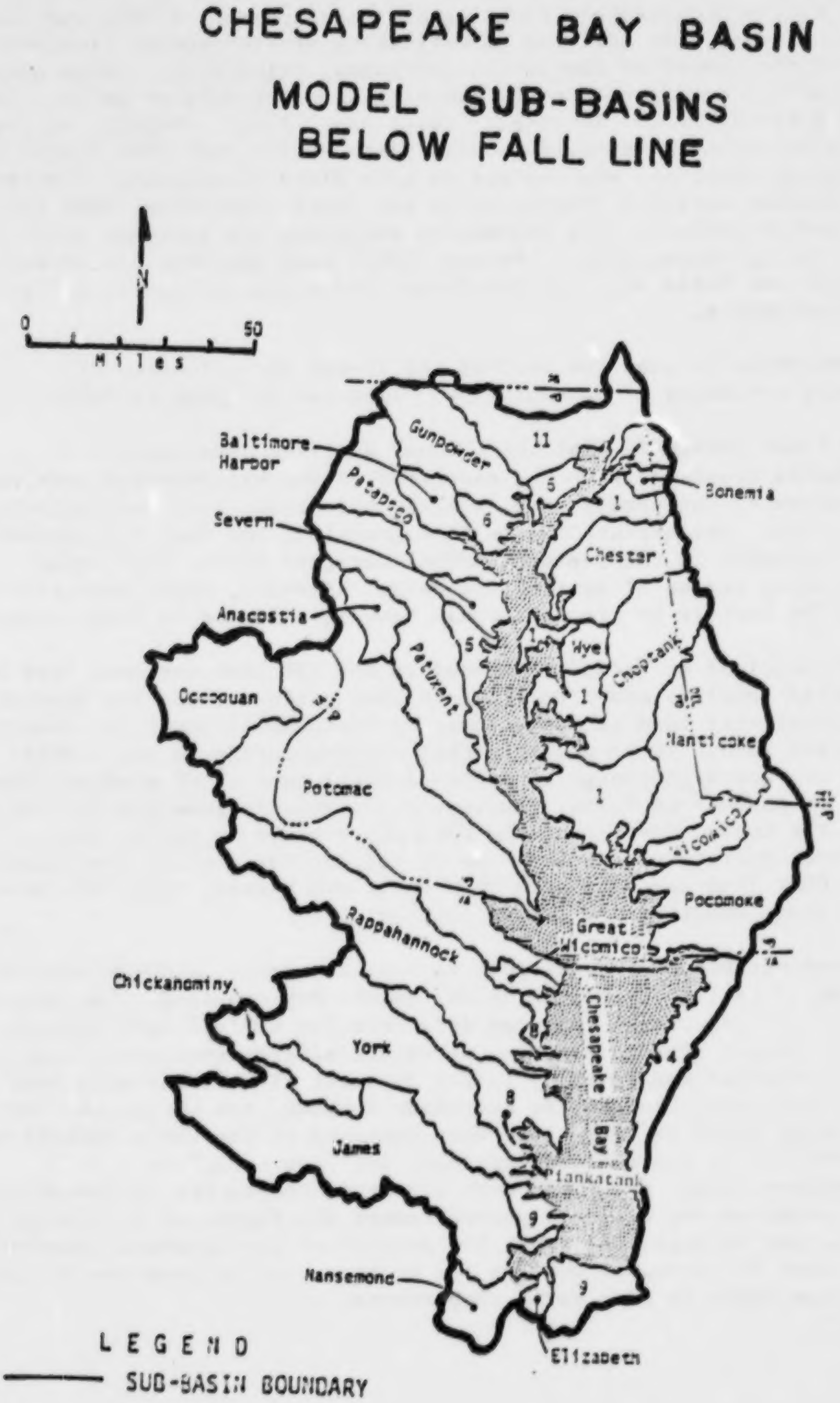


Figure 35. Chesapeake Bay basin model sub-basins below the fall line

The CBP management study used the basin model to predict nutrient loadings to the Chesapeake's tidal waters under present (1980) and future (2000) conditions. In addition to estimating greater sewage treatment plant loadings (based on population increases, primarily), future nonpoint source loadings were generated by changing land-use data to account for increasing development. To make a "worst case" future nonpoint source load, all development expected to take place by the year 2000 (based on population projections) was assumed to take place on existing forested areas. Because nutrient loading rates are least from forest land compared to cropland or pasture, this assumption maximizes the increase in nutrient loadings due to urbanization. Future (2000) land use data are presented in Table 12(b) and Table 13; only the forest and urban categories differ from the 1980 estimates.

A comparison between the LANDSAT and Timber Survey/Census of Agriculture estimates of present (1980) land-use is shown in Table 15.

This table indicates that the LANDSAT analysis consistently overestimates cropland, with the exception of the Rappahannock, and pasture land compared to the Census data, whereas the Census data overestimate "other" lands. One explanation is that grassland not used for pasture was probably included in the pasture LANDSAT category and in the "other" category using census of Agriculture data. Likewise, other vegetated lands not used for pasture or cropland could have been placed in these categories.

When "woodland or farms" (included in the CBP land use data base but not reported here) is added to cropland plus pasture land, the percent total agricultural land is much closer to the LANDSAT total for cropland plus pasture land. It is possible that the resolution in the LANDSAT analysis was not high enough to separate small parcels of woodland from cropland or pasture on farms, however, it is equally possible for the error to be in the Census data since the latter are based on survey data. Nonetheless, differences as large as 10 percent for similar land uses indicate that land-use data sets have their own biases; thus, one should be cautious when comparing one set to another.

Another example of the inherent variability among land-use data is the estimation of tillage practices on Chesapeake Bay cropland. The Maryland Department of Agriculture compared data from the CBP/SCS Agricultural Activities Report (Appendix C) on the extent of conservation-tillage practices (minimum and no-till) in the Patuxent River basin with data from a new SCS analysis, Cooperative Extension Service, and Chesapeake Bay Program data, shown in Table 16. When compared to the CBP's LANDSAT data on "high-till," or conventional-tillage, and "low-till," or conservation-tillage, one finds even larger discrepancies (although the LANDSAT estimates are strictly geared toward the degree of vegetative soil cover, and not tillage, *per se*). The purpose of any land-use/land-cover data set must be known, as well as the methods used to generate it, only then can one begin to make valid comparisons.

TABLE 12. PRESENT (A) AND FUTURE (B) LAND USE BY MAJOR BASIN AND BY REACH (ABOVE THE FALL LINE) AND COASTAL SUB-BASIN (BELOW THE FALL LINE) IN THE CHESAPEAKE BAY BASIN, BASED ON LANDSAT ANALYSIS.

12A. Present Land Use

SUSQUEHANNA

| REACH | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES (10²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH10 | 53.47 | 0.00 | 1.76 | 21.07 | 22.38 | 0.00 | 0.00 | 0.00 | 1.32 | 53.47 | 22.83 | 22.38 | 1.32 | 16627.2 |
| RCH20 | 57.25 | 0.00 | 1.98 | 14.53 | 24.31 | 0.00 | 0.00 | 0.00 | 1.93 | 57.25 | 16.51 | 24.31 | 1.93 | 31705.6 |
| RCH30 | 57.54 | 0.00 | 2.08 | 21.18 | 15.20 | 0.00 | 0.00 | 0.00 | 4.00 | 57.54 | 23.26 | 15.20 | 4.00 | 15411.2 |
| RCH40 | 59.48 | 0.00 | 1.89 | 20.83 | 12.58 | 0.02 | 0.00 | 0.00 | 5.20 | 59.48 | 22.72 | 12.58 | 5.22 | 8940.8 |
| RCH50 | 72.61 | 0.00 | 4.50 | 9.24 | 10.90 | 0.00 | 0.00 | 0.00 | 2.75 | 72.61 | 13.74 | 10.90 | 2.75 | 9356.8 |
| RCH60 | 80.04 | 0.00 | 0.92 | 6.73 | 11.65 | 0.00 | 0.00 | 0.00 | 0.66 | 80.04 | 7.65 | 11.65 | 0.66 | 27008.0 |
| RCH70 | 64.51 | 0.00 | 3.07 | 21.10 | 8.38 | 0.00 | 0.00 | 0.00 | 2.94 | 64.51 | 24.17 | 8.38 | 2.94 | 8070.4 |
| RCH80 | 59.87 | 0.00 | 1.61 | 19.12 | 16.61 | 0.24 | 0.05 | 0.03 | 2.47 | 59.87 | 20.73 | 16.61 | 2.79 | 15270.4 |
| RCH90 | 70.64 | 0.00 | 1.40 | 6.75 | 19.12 | 0.00 | 0.00 | 0.00 | 2.09 | 70.64 | 8.15 | 19.12 | 2.09 | 6144.0 |
| RCH100 | 74.45 | 0.00 | 1.67 | 8.75 | 14.19 | 0.00 | 0.00 | 0.00 | 0.94 | 74.45 | 10.42 | 14.19 | 0.94 | 15705.6 |
| RCH110 | 37.38 | 0.00 | 5.01 | 26.62 | 25.85 | 1.60 | 0.42 | 0.10 | 3.02 | 37.38 | 31.63 | 25.85 | 5.14 | 12096.0 |
| RCH120 | 37.41 | 0.00 | 3.41 | 34.17 | 21.15 | 0.77 | 0.08 | 0.21 | 2.80 | 37.41 | 37.58 | 21.15 | 3.86 | 5145.6 |
| RCH140 | 37.41 | 0.00 | 3.41 | 34.17 | 21.15 | 0.77 | 0.08 | 0.21 | 2.80 | 37.41 | 37.58 | 21.15 | 3.86 | 1958.4 |

EASTERN SHORE

| COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOHEM | 27.83 | 0.00 | 4.77 | 52.94 | 14.46 | 0.00 | 0.00 | 0.00 | 0.00 | 27.83 | 57.71 | 14.46 | 0.00 | 362.4 |
| COAST1 | 54.01 | 0.00 | 4.62 | 32.73 | 7.07 | 0.29 | 0.17 | 0.17 | 0.94 | 54.01 | 37.35 | 7.07 | 1.57 | 4046.5 |
| COAST4 | 54.01 | 0.00 | 4.62 | 32.73 | 7.07 | 0.29 | 0.17 | 0.17 | 0.94 | 54.01 | 37.35 | 7.07 | 1.57 | 1905.5 |
| CHEST | 35.58 | 0.00 | 7.76 | 47.41 | 8.61 | 0.24 | 0.07 | 0.14 | 0.19 | 35.58 | 55.17 | 8.61 | 0.64 | 2627.4 |
| CHOPT | 39.72 | 0.00 | 3.78 | 44.81 | 10.60 | 0.49 | 0.13 | 0.28 | 0.19 | 39.72 | 48.59 | 10.60 | 1.09 | 3793.7 |
| NANTI | 49.66 | 0.00 | 6.50 | 35.56 | 7.07 | 0.29 | 0.12 | 0.37 | 0.43 | 49.66 | 42.06 | 7.07 | 1.21 | 5155.2 |
| POCOM | 68.52 | 0.00 | 1.06 | 24.50 | 4.06 | 0.32 | 0.06 | 0.17 | 1.31 | 68.52 | 25.56 | 4.06 | 1.86 | 4479.0 |
| WICOM | 51.00 | 0.00 | 8.58 | 26.36 | 7.98 | 1.79 | 0.97 | 2.75 | 0.58 | 51.00 | 34.94 | 7.98 | 6.09 | 1275.8 |
| WYE | 28.51 | 0.00 | 4.40 | 55.25 | 11.32 | 0.00 | 0.00 | 0.00 | 0.52 | 28.51 | 59.65 | 11.32 | 0.52 | 800.5 |

WEST CHESAPEAKE

| COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COAST5 | 65.50 | 0.00 | 0.40 | 11.32 | 13.53 | 6.26 | 1.16 | 1.07 | 0.76 | 65.50 | 11.72 | 13.53 | 9.25 | 1321.7 |
| COAST6 | 37.59 | 0.00 | 3.04 | 23.33 | 3.82 | 12.84 | 6.86 | 9.43 | 3.09 | 37.59 | 26.37 | 3.82 | 32.22 | 308.2 |
| COST11 | 46.39 | 0.00 | 3.14 | 24.94 | 22.68 | 1.90 | 0.57 | 0.28 | 0.10 | 46.39 | 28.08 | 22.68 | 2.85 | 4658.0 |
| BALTI | 17.38 | 0.00 | 1.29 | 11.57 | 11.00 | 25.89 | 9.04 | 13.82 | 10.01 | 17.38 | 12.86 | 11.00 | 58.76 | 1010.3 |
| GUNPO | 46.97 | 0.00 | 2.78 | 21.51 | 19.76 | 2.63 | 2.52 | 1.49 | 2.35 | 46.97 | 24.29 | 19.76 | 8.98 | 2791.2 |
| PATAP | 39.66 | 0.00 | 1.92 | 21.39 | 22.82 | 4.76 | 2.88 | 2.67 | 3.90 | 39.66 | 23.31 | 22.82 | 14.21 | 2708.4 |
| SEVER | 66.82 | 0.00 | 2.32 | 9.12 | 4.83 | 10.17 | 2.75 | 3.14 | 0.85 | 66.82 | 11.44 | 4.83 | 16.91 | 376.4 |

PATUXENT

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 53.10 | 0.00 | 1.07 | 19.52 | 20.73 | 2.80 | 1.72 | 0.62 | 0.44 | 53.10 | 20.59 | 20.73 | 5.58 | 2227.2 |
| LPATX | 53.10 | 0.00 | 1.07 | 19.52 | 20.73 | 2.80 | 1.72 | 0.62 | 0.44 | 53.10 | 20.59 | 20.73 | 5.58 | 3430.3 |

(continued)

TABLE 12. (continued)

12B. Future Land Use.

Susquehanna

| REACH | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH10 | 53.37 | 0.00 | 1.76 | 21.07 | 22.38 | 0.00 | 0.00 | 0.00 | 1.42 | 53.37 | 22.83 | 22.38 | 1.42 | 16627.2 |
| RCH20 | 57.01 | 0.00 | 1.98 | 14.53 | 24.31 | 0.00 | 0.00 | 0.00 | 2.17 | 57.01 | 16.51 | 24.31 | 2.17 | 31705.6 |
| RCH30 | 57.12 | 0.00 | 2.08 | 21.18 | 15.20 | 0.00 | 0.00 | 0.00 | 4.42 | 57.12 | 23.26 | 15.20 | 4.42 | 15411.2 |
| RCH40 | 58.90 | 0.00 | 1.89 | 20.83 | 12.58 | 0.02 | 0.00 | 0.00 | 5.77 | 58.90 | 22.72 | 12.58 | 5.80 | 8940.8 |
| RCH50 | 72.46 | 0.00 | 4.59 | 9.24 | 10.90 | 0.00 | 0.00 | 0.00 | 2.90 | 72.46 | 13.74 | 10.90 | 2.90 | 9356.8 |
| RCH60 | 79.95 | 0.00 | 0.92 | 6.73 | 11.65 | 0.00 | 0.00 | 0.00 | 0.75 | 79.95 | 7.65 | 11.65 | 0.75 | 27008.0 |
| RCH70 | 64.21 | 0.00 | 3.07 | 21.10 | 8.38 | 0.00 | 0.00 | 0.00 | 3.24 | 64.21 | 24.17 | 8.38 | 3.24 | 8070.4 |
| RCH80 | 59.58 | 0.00 | 1.61 | 19.12 | 16.61 | 0.26 | 0.06 | 0.03 | 2.72 | 59.58 | 20.73 | 16.61 | 3.09 | 15270.4 |
| RCH90 | 70.41 | 0.00 | 1.40 | 6.75 | 19.12 | 0.00 | 0.00 | 0.00 | 2.32 | 70.41 | 8.15 | 19.12 | 2.32 | 6144.0 |
| RCH100 | 74.37 | 0.00 | 1.67 | 8.75 | 14.19 | 0.00 | 0.00 | 0.00 | 1.02 | 74.37 | 10.42 | 14.19 | 1.02 | 15705.6 |
| RCH110 | 36.55 | 0.00 | 5.01 | 26.62 | 25.85 | 1.86 | 0.49 | 0.12 | 3.51 | 36.55 | 31.63 | 25.85 | 5.97 | 12096.0 |
| RCH120 | 36.83 | 0.00 | 3.41 | 34.17 | 21.15 | 0.88 | 0.09 | 0.24 | 3.22 | 36.83 | 37.58 | 21.15 | 4.44 | 5145.6 |
| RCH140 | 37.41 | 0.00 | 3.41 | 34.17 | 21.15 | 0.77 | 0.08 | 0.21 | 2.80 | 37.41 | 37.58 | 21.15 | 3.86 | 1958.4 |

EASTERN SHORE

| COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES ($10^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOHEM | 27.83 | 0.00 | 4.77 | 52.94 | 14.46 | 0.00 | 0.00 | 0.00 | 0.00 | 27.83 | 57.71 | 14.46 | 0.00 | 362.4 |
| COAST1 | 53.81 | 0.00 | 4.62 | 32.73 | 7.07 | 0.33 | 0.19 | 0.19 | 1.06 | 53.81 | 37.35 | 7.07 | 1.77 | 4046.5 |
| COAST4 | 53.76 | 0.00 | 4.62 | 32.73 | 7.07 | 0.34 | 0.20 | 0.20 | 1.09 | 53.76 | 37.35 | 7.07 | 1.82 | 1905.5 |
| CHEST | 35.37 | 0.00 | 7.76 | 47.41 | 8.61 | 0.32 | 0.09 | 0.19 | 0.25 | 35.37 | 55.17 | 8.61 | 0.85 | 2627.4 |
| CHOPT | 39.39 | 0.00 | 3.78 | 44.81 | 10.60 | 0.64 | 0.17 | 0.37 | 0.25 | 39.39 | 48.59 | 10.60 | 1.42 | 3793.7 |
| NANTI | 49.35 | 0.00 | 6.50 | 35.56 | 7.07 | 0.37 | 0.15 | 0.47 | 0.54 | 49.35 | 42.06 | 7.07 | 1.52 | 5155.2 |
| POCOM | 68.24 | 0.00 | 1.06 | 24.50 | 4.06 | 0.37 | 0.07 | 0.20 | 1.50 | 68.24 | 25.56 | 4.06 | 2.14 | 4479.0 |
| WICOM | 49.96 | 0.00 | 8.58 | 26.36 | 7.98 | 2.09 | 1.14 | 3.22 | 0.68 | 49.96 | 34.94 | 7.98 | 7.12 | 1275.8 |
| WYE | 28.51 | 0.00 | 4.40 | 55.25 | 11.32 | 0.00 | 0.00 | 0.00 | 0.52 | 28.51 | 59.65 | 11.32 | 0.52 | 809.5 |

WEST CHESAPEAKE

| COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COAST5 | 62.33 | 0.00 | 0.40 | 11.32 | 13.53 | 8.41 | 1.56 | 1.44 | 1.02 | 62.33 | 11.72 | 13.53 | 12.42 | 1321.7 |
| COAST6 | 39.57 | 0.00 | 3.04 | 23.33 | 3.82 | 12.05 | 6.44 | 8.85 | 2.90 | 39.57 | 26.37 | 3.82 | 30.24 | 308.2 |
| COST11 | 45.85 | 0.00 | 3.14 | 24.94 | 22.68 | 2.26 | 0.68 | 0.33 | 0.12 | 45.85 | 28.08 | 22.68 | 3.39 | 4658.0 |
| BALTI | 22.44 | 0.00 | 1.29 | 11.57 | 11.00 | 23.66 | 8.26 | 12.63 | 9.15 | 22.44 | 12.86 | 11.00 | 53.70 | 1010.3 |
| GUNPO | 46.29 | 0.00 | 2.78 | 21.51 | 19.76 | 2.83 | 2.71 | 1.59 | 2.53 | 46.29 | 24.29 | 19.76 | 9.66 | 2791.2 |
| PATAP | 34.13 | 0.00 | 1.92 | 21.39 | 22.82 | 6.61 | 4.00 | 3.71 | 5.42 | 34.13 | 23.31 | 22.82 | 19.74 | 2708.4 |
| SEVER | 61.88 | 0.00 | 2.32 | 9.12 | 4.83 | 13.14 | 3.55 | 4.06 | 1.10 | 61.88 | 11.44 | 4.83 | 21.85 | 376.4 |

PATUXENT

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES ($10^2$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCHPAT | 51.85 | 0.00 | 1.07 | 19.52 | 20.73 | 3.41 | 2.11 | 0.76 | 0.54 | 51.85 | 20.59 | 20.73 | 6.83 | 2227.2 |
| LPATX | 51.70 | 0.00 | 1.07 | 19.52 | 20.73 | 3.50 | 2.15 | 0.78 | 0.55 | 51.70 | 20.59 | 20.73 | 6.98 | 3430.3 |

(continued)

TABLE 12. (continued)

POTOMAC

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH160 | 80.84 | 0.00 | 0.44 | 5.65 | 11.32 | 0.00 | 0.00 | 0.00 | 1.75 | 80.84 | 6.09 | 11.32 | 1.75 | 8560.6 |
| RCH170 | 76.28 | 0.00 | 0.49 | 12.07 | 10.70 | 0.01 | 0.01 | 0.02 | 0.42 | 76.28 | 12.56 | 10.70 | 0.46 | 9555.2 |
| RCH175 | 80.84 | 0.00 | 0.44 | 5.65 | 11.32 | 0.00 | 0.00 | 0.00 | 1.75 | 80.84 | 6.09 | 11.32 | 1.75 | 7942.4 |
| RCH180 | 57.87 | 0.00 | 1.99 | 17.25 | 21.04 | 0.86 | 0.08 | 0.16 | 0.75 | 57.87 | 19.24 | 21.04 | 1.85 | 16115.2 |
| RCH190 | 60.48 | 0.00 | 2.70 | 15.17 | 20.73 | 0.28 | 0.25 | 0.27 | 0.12 | 60.48 | 17.87 | 20.73 | 0.92 | 10508.8 |
| RCH200 | 59.08 | 0.00 | 2.29 | 15.56 | 22.42 | 0.27 | 0.06 | 0.09 | 0.23 | 59.08 | 17.85 | 22.42 | 0.65 | 9075.2 |
| RCH210 | 41.03 | 0.00 | 4.94 | 26.64 | 25.74 | 0.57 | 0.39 | 0.20 | 0.39 | 41.03 | 31.58 | 25.74 | 1.55 | 6348.8 |
| RCH220 | 41.40 | 0.00 | 2.72 | 19.82 | 25.66 | 6.31 | 1.64 | 0.38 | 2.07 | 41.40 | 22.54 | 25.66 | 10.40 | 5932.8 |
| ANACO | 18.17 | 0.00 | 0.95 | 13.13 | 17.25 | 28.34 | 6.40 | 9.64 | 6.12 | 18.17 | 14.08 | 17.25 | 50.50 | 813.6 |
| OCCOQ | 62.66 | 0.00 | 1.49 | 12.07 | 19.90 | 1.67 | 0.76 | 0.42 | 1.04 | 62.66 | 13.56 | 19.90 | 3.89 | 3863.4 |
| POTOM | 54.47 | 0.00 | 2.11 | 13.12 | 15.90 | 8.48 | 3.11 | 1.32 | 1.49 | 54.47 | 15.23 | 15.90 | 14.40 | 11730.5 |

RAPPAHANNOCK-YORK

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH230 | 61.42 | 0.00 | 0.99 | 11.09 | 26.21 | 0.09 | 0.06 | 0.02 | 0.12 | 61.42 | 12.08 | 26.21 | 0.29 | 10214.4 |
| RCH235 | 74.71 | 0.00 | 2.61 | 12.34 | 9.39 | 0.30 | 0.04 | 0.04 | 0.57 | 74.71 | 14.95 | 9.39 | 0.95 | 1644.8 |
| RCH240 | 74.71 | 0.00 | 2.61 | 12.34 | 9.39 | 0.30 | 0.04 | 0.04 | 0.57 | 74.71 | 14.95 | 9.39 | 0.95 | 2201.6 |
| RCH250 | 71.69 | 0.00 | 1.97 | 11.33 | 14.91 | 0.02 | 0.01 | 0.01 | 0.06 | 71.69 | 13.30 | 14.91 | 0.10 | 2195.2 |
| RCH260 | 71.69 | 0.00 | 1.97 | 11.33 | 14.91 | 0.02 | 0.01 | 0.01 | 0.06 | 71.69 | 13.30 | 14.91 | 0.10 | 4723.2 |
| GREAT | 66.32 | 0.00 | 2.00 | 17.63 | 14.05 | 0.00 | 0.00 | 0.00 | 0.00 | 66.32 | 19.63 | 14.05 | 0.00 | 414.9 |
| RAPPA | 62.20 | 0.00 | 2.86 | 18.78 | 15.10 | 0.58 | 0.28 | 0.19 | 0.01 | 62.20 | 21.64 | 15.10 | 1.06 | 5916.1 |
| COAST8 | 71.84 | 0.00 | 2.03 | 14.64 | 11.49 | 0.00 | 0.00 | 0.00 | 0.00 | 71.84 | 16.67 | 11.49 | 0.00 | 293.4 |
| YORK | 68.82 | 0.00 | 2.16 | 17.10 | 11.87 | 0.00 | 0.00 | 0.00 | 0.05 | 68.82 | 19.26 | 11.87 | 0.05 | 5866.0 |
| PIANK | 71.74 | 0.00 | 2.03 | 14.64 | 11.49 | 0.05 | 0.00 | 0.00 | 0.05 | 71.74 | 16.67 | 11.49 | 0.10 | 2482.3 |

JAMES

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH270 | 81.36 | 0.08 | 0.81 | 5.01 | 12.28 | 0.07 | 0.10 | 0.04 | 0.25 | 81.44 | 5.82 | 12.28 | 0.46 | 20857.6 |
| RCH280 | 74.74 | 0.00 | 0.43 | 7.66 | 16.07 | 0.28 | 0.27 | 0.16 | 0.39 | 74.74 | 8.09 | 16.07 | 1.10 | 19187.2 |
| RCH290 | 65.23 | 0.00 | 1.45 | 10.74 | 14.62 | 4.81 | 0.37 | 0.57 | 2.21 | 65.23 | 12.19 | 14.62 | 7.96 | 3206.4 |
| RCH300 | 68.55 | 0.00 | 2.27 | 13.16 | 14.72 | 0.08 | 0.06 | 0.04 | 1.12 | 68.55 | 15.43 | 14.72 | 1.30 | 7686.4 |
| RCH310 | 68.55 | 0.00 | 2.27 | 13.16 | 14.72 | 0.08 | 0.06 | 0.04 | 1.12 | 68.55 | 15.43 | 14.72 | 1.30 | 857.6 |
| RCH320 | 68.55 | 0.00 | 2.27 | 13.16 | 14.72 | 0.08 | 0.06 | 0.04 | 1.12 | 68.55 | 15.43 | 14.72 | 1.30 | 57.6 |
| COAST9 | 59.19 | 0.00 | 0.65 | 9.76 | 14.00 | 2.74 | 7.97 | 3.09 | 2.60 | 59.19 | 10.41 | 14.00 | 16.40 | 1933.7 |
| CHICK | 56.94 | 0.00 | 2.26 | 20.76 | 7.68 | 6.90 | 1.87 | 2.56 | 1.03 | 56.94 | 23.02 | 7.68 | 12.36 | 1595.2 |
| ELIZA | 33.98 | 0.00 | 0.67 | 8.89 | 21.59 | 8.75 | 13.01 | 6.03 | 7.08 | 33.98 | 9.56 | 21.59 | 34.87 | 161.6 |
| JAMES | 62.68 | 0.00 | 2.62 | 14.02 | 10.81 | 3.28 | 2.07 | 2.22 | 2.30 | 62.68 | 16.64 | 10.81 | 9.87 | 8357.6 |
| NANSE | 53.47 | 0.00 | 4.46 | 22.51 | 18.61 | 0.25 | 0.08 | 0.08 | 0.54 | 53.47 | 26.97 | 18.61 | 0.95 | 1348.1 |

(continued)

TABLE 12. (continued)

POTOMAC

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES ($10^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH160 | 80.69 | 0.00 | 0.44 | 5.65 | 11.32 | 0.00 | 0.00 | 0.00 | 1.90 | 80.69 | 6.09 | 11.32 | 1.90 | 8569.6 |
| RCH170 | 76.17 | 0.00 | 0.49 | 12.07 | 10.70 | 0.01 | 0.01 | 0.02 | 0.52 | 76.17 | 12.56 | 10.70 | 0.57 | 9555.2 |
| RCH175 | 80.73 | 0.00 | 0.44 | 5.65 | 11.32 | 0.00 | 0.00 | 0.00 | 1.86 | 80.73 | 6.09 | 11.32 | 1.86 | 7942.4 |
| RCH180 | 57.60 | 0.00 | 1.99 | 17.25 | 21.04 | 0.99 | 0.09 | 0.19 | 0.86 | 57.60 | 12.24 | 21.04 | 2.12 | 16115.2 |
| RCH190 | 60.29 | 0.00 | 2.10 | 15.17 | 20.73 | 0.34 | 0.30 | 0.33 | 0.15 | 60.29 | 17.87 | 20.73 | 1.11 | 10508.8 |
| RCH200 | 58.82 | 0.00 | 2.29 | 15.56 | 22.42 | 0.38 | 0.08 | 0.13 | 0.32 | 58.82 | 17.85 | 22.42 | 0.91 | 9075.2 |
| RCH210 | 40.52 | 0.00 | 4.94 | 26.64 | 25.74 | 0.88 | 0.51 | 0.26 | 0.51 | 40.52 | 31.58 | 25.74 | 2.16 | 6348.8 |
| RCH220 | 38.62 | 0.00 | 2.72 | 19.82 | 25.66 | 8.00 | 2.08 | 0.49 | 2.62 | 38.62 | 22.54 | 25.66 | 13.18 | 5932.8 |
| ANACO | 15.33 | 0.00 | 0.95 | 13.13 | 17.25 | 29.93 | 6.76 | 10.18 | 6.46 | 15.33 | 14.08 | 17.25 | 53.34 | 813.6 |
| OCCO | 60.10 | 0.00 | 1.48 | 12.07 | 19.90 | 2.77 | 1.26 | 0.70 | 1.72 | 60.10 | 13.55 | 19.90 | 6.45 | 3863.4 |
| POTOM | 53.36 | 0.00 | 2.11 | 13.12 | 15.90 | 9.14 | 3.35 | 1.42 | 1.61 | 53.36 | 15.23 | 15.90 | 15.51 | 11730.5 |

RAPPAHANNOCK-YORK

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH230 R | 61.30 | 0.00 | 0.99 | 11.09 | 26.21 | 0.13 | 0.08 | 0.03 | 0.17 | 61.30 | 12.08 | 26.21 | 0.41 | 10214.4 |
| RCH235 R | 73.81 | 0.00 | 2.51 | 12.34 | 9.39 | 0.59 | 0.08 | 0.08 | 1.11 | 73.81 | 14.95 | 9.39 | 1.85 | 1644.8 |
| RCH240 R | 74.31 | 0.00 | 2.61 | 12.34 | 9.39 | 0.43 | 0.06 | 0.06 | 0.81 | 74.31 | 14.95 | 9.39 | 1.35 | 2201.6 |
| RCH250 Y | 71.64 | 0.00 | 1.97 | 11.33 | 14.91 | 0.03 | 0.02 | 0.02 | 0.09 | 71.64 | 13.30 | 14.91 | 0.15 | 2195.2 |
| RCH260 Y | 71.63 | 0.00 | 1.97 | 11.33 | 14.91 | 0.03 | 0.02 | 0.02 | 0.09 | 71.63 | 13.30 | 14.91 | 0.14 | 4723.2 |
| GREAT R | 66.32 | 0.00 | 2.00 | 17.63 | 14.05 | 0.00 | 0.00 | 0.00 | 0.00 | 66.32 | 19.63 | 14.05 | 0.00 | 414.9 |
| RAPPA R | 61.95 | 0.00 | 2.86 | 18.78 | 15.10 | 0.71 | 0.35 | 0.23 | 0.01 | 61.95 | 21.64 | 15.10 | 1.31 | 5916.1 |
| COAST8 Y | 71.84 | 0.00 | 2.03 | 14.64 | 11.49 | 0.00 | 0.00 | 0.00 | 0.00 | 71.84 | 15.67 | 11.49 | 0.00 | 293.4 |
| YORK Y | 68.82 | 0.00 | 2.16 | 17.10 | 11.87 | 0.00 | 0.00 | 0.00 | 0.05 | 68.82 | 19.26 | 11.87 | 0.05 | 5866.0 |
| PIANK Y | 71.74 | 0.00 | 2.03 | 14.64 | 11.49 | 0.05 | 0.00 | 0.00 | 0.05 | 71.74 | 15.67 | 11.49 | 0.10 | 2492.3 |

JAMES

| REACH/ COASTAL SUB-BASIN | FOREST | IDLE | C_TILL | M_TILL | PASTURE | L_LOT | M_DEN | TH_GA | C_I | FOR_IDLE | CROP | PASTURE | URBAN1 | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCH270 | 81.33 | 0.08 | 0.81 | 5.01 | 12.28 | 0.08 | 0.11 | 0.04 | 0.27 | 81.41 | 5.82 | 12.28 | 0.49 | 20857.6 |
| RCH280 | 74.54 | 0.00 | 0.43 | 7.66 | 16.07 | 0.33 | 0.32 | 0.19 | 0.46 | 74.54 | 8.09 | 16.07 | 1.30 | 19187.2 |
| RCH290 | 63.05 | 0.00 | 1.45 | 10.74 | 14.62 | 6.13 | 0.47 | 0.73 | 2.82 | 63.05 | 12.19 | 14.62 | 10.14 | 3206.4 |
| RCH300 | 68.39 | 0.00 | 2.27 | 13.16 | 14.72 | 0.09 | 0.07 | 0.04 | 1.25 | 68.39 | 15.43 | 14.72 | 1.46 | 7686.4 |
| RCH310 | 68.39 | 0.00 | 2.27 | 13.16 | 14.72 | 0.09 | 0.07 | 0.04 | 1.25 | 68.39 | 15.43 | 14.72 | 1.46 | 857.6 |
| RCH320 | 68.39 | 0.00 | 2.27 | 13.16 | 14.72 | 0.09 | 0.07 | 0.04 | 1.25 | 68.39 | 15.43 | 14.72 | 1.46 | 57.6 |
| COAST9 | 58.20 | 0.00 | 0.65 | 9.76 | 14.00 | 2.91 | 8.45 | 3.28 | 2.76 | 58.20 | 10.41 | 14.00 | 17.39 | 1933.7 |
| CHICK | 49.02 | 0.00 | 2.26 | 20.76 | 7.68 | 11.32 | 3.07 | 4.20 | 1.69 | 49.02 | 23.02 | 7.68 | 20.28 | 1595.2 |
| ELIZA | 33.51 | 0.00 | 0.67 | 8.89 | 21.59 | 8.87 | 13.18 | 6.11 | 7.18 | 33.51 | 9.56 | 21.59 | 35.34 | 161.6 |
| JAMES | 61.17 | 0.00 | 2.62 | 14.02 | 10.81 | 3.78 | 2.39 | 2.56 | 2.65 | 61.17 | 16.64 | 10.81 | 11.38 | 8357.6 |
| NANSE | 53.27 | 0.00 | 4.46 | 22.51 | 18.61 | 0.30 | 0.10 | 0.10 | 0.65 | 53.27 | 26.97 | 18.61 | 1.15 | 1348.1 |

## LEGEND TO TABLE 12.

- AGRICULTURAL
  - CROP=CROPLAND
    - C_TILL=CONVENTIONAL TILLAGE
    - M_TILL=MINIMUM TILLAGE
  - PASTURE=PASTURE
- URBAN
  - L_LOT=LARGE LOT
  - M_DEN=MEDIUM DENSITY
  - TH_GA=TOWNHOUSE-GARDEN
  - C_I=COMMERCIAL-INDUSTRIAL
- FOREST
  - FOREST=FOREST
  - FOR_IDLE=FOREST+IDLE

TABLE 13. SUMMARY OF EXISTING (1980) and FUTURE (2000) LAND USAGE BY MAJOR BASIN.

| BASIN | TIME | FOREST | IDLE | C-TILL | M-TILL | PASTURE | L-LOT | M-DEN | TH-GA | C-I | FOR-IDLE | CROP | PASTURE | URBAN | ACRES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUSQUEHANNA | EXISTING | 61.81 | 0.00 | 2.17 | 16.13 | 17.47 | 0.17 | 0.04 | 0.02 | 2.19 | 61.81 | 18.30 | 17.47 | 2.41 | 173440.0 |
|  | FUTURE | 61.54 | 0.00 | 2.17 | 16.13 | 17.47 | 0.17 | 0.04 | 0.02 | 2.19 | 61.54 | 18.30 | 17.47 | 2.68 | 173440.0 |
| EASTERN SHORE | EXISTING | 50.16 | 0.00 | 4.77 | 35.98 | 7.53 | 0.38 | 0.16 | 0.35 | 0.66 | 50.16 | 40.76 | 7.53 | 1.55 | 24455.0 |
|  | FUTURE | 49.87 | 0.00 | 4.77 | 35.98 | 7.53 | 0.47 | 0.19 | 0.43 | 0.77 | 49.87 | 40.76 | 7.53 | 1.85 | 24455.0 |
| WEST CHESAPEAKE | EXISTING | 45.20 | 0.00 | 2.37 | 20.60 | 19.33 | 5.41 | 2.38 | 2.44 | 2.28 | 45.20 | 22.97 | 19.33 | 12.50 | 13174.2 |
|  | FUTURE | 43.70 | 0.00 | 2.37 | 20.60 | 19.33 | 6.07 | 2.68 | 2.65 | 2.59 | 43.70 | 22.97 | 19.33 | 14.00 | 13174.2 |
| POTOMAC | EXISTING | 61.58 | 0.00 | 1.90 | 14.21 | 18.16 | 2.10 | 0.68 | 0.39 | 0.99 | 61.58 | 16.11 | 18.16 | 4.16 | 90455.5 |
|  | FUTURE | 60.95 | 0.00 | 1.90 | 14.21 | 18.16 | 2.41 | 0.78 | 0.44 | 1.15 | 60.95 | 16.11 | 18.16 | 4.78 | 90455.5 |
| RAPPAHANNOCK-YORK | EXISTING | 67.01 | 0.00 | 1.94 | 13.87 | 16.79 | 0.16 | 0.07 | 0.04 | 0.12 | 67.01 | 15.81 | 16.79 | 0.39 | 35951.9 |
|  | FUTURE | 66.86 | 0.00 | 1.94 | 13.87 | 16.79 | 0.22 | 0.09 | 0.06 | 0.18 | 66.86 | 15.81 | 16.79 | 0.54 | 35951.9 |
| PATUXENT | EXISTING | 53.10 | 0.00 | 1.07 | 19.52 | 20.73 | 2.80 | 1.72 | 0.62 | 0.44 | 53.10 | 20.59 | 20.73 | 5.58 | 5657.5 |
|  | FUTURE | 51.76 | 0.00 | 1.07 | 19.52 | 20.73 | 3.47 | 2.13 | 0.77 | 0.55 | 51.76 | 20.59 | 20.73 | 6.92 | 5657.5 |
| JAMES | EXISTING | 72.59 | 0.03 | 1.26 | 9.20 | 13.74 | 1.05 | 0.72 | 0.55 | 0.88 | 72.62 | 10.46 | 13.74 | 3.19 | 65249.0 |
|  | FUTURE | 71.97 | 0.03 | 1.26 | 9.20 | 13.74 | 1.31 | 0.83 | 0.66 | 1.02 | 72.00 | 10.46 | 13.74 | 3.81 | 65249.0 |
| TOTAL | EXISTING | 62.58 |  | 2.09 | 15.78 | 16.48 | 0.96 | 0.3 | 0.30 | 1.92 |  | 17.87 | 16.48 | 3.07 | 408383.1 |
|  | FUTURE | 62.13 |  | 2.09 | 15.78 | 16.48 | 1.12 | 0.46 | 0.34 | 1.60 |  | 17.87 | 16.48 | 3.52 | 408383.1 |
| ABOVE THE FALL LINE | EXISTING | 64.66 |  |  |  |  |  |  |  |  |  | 15.99 | 17.32 | 2.04 | 322547.2 |
|  | FUTURE | 64.35 |  |  |  |  |  |  |  |  |  | 15.99 | 17.32 | 2.34 | 322547.2 |
| BELOW THE FALL LINE | EXISTING | 54.82 |  |  |  |  |  |  |  |  |  | 24.95 | 13.31 | 6.93 | 85835.9 |
|  | FUTURE | 53.81 |  |  |  |  |  |  |  |  |  | 24.95 | 13.31 | 7.93 | 85835.9 |

TABLE 14. REACHES AND SUB-BASINS (ILLUSTRATED IN FIGURES 35 AND 36) CORRESPONDING TO MINOR SUB-BASINS OF THE CHESAPEAKE BAY BASIN

| | Reach or Sub-basin |
|---|---|
| Susquehanna | |
| Above Sunbury | 10, 20, 30, 40 |
| West Branch | 50, 60, 70 |
| Sunbury to Harrisburg | 80 |
| Juniata | 90, 100 |
| Below Harrisburg | 110, 120, 140 |
| Eastern Shore | See Table 12 |
| Patuxent | See Table 12 |
| West Chesapeake | See Table 12 |
| Potomac | |
| Above fall line | 160, 170, 175, 180, 190, 200, 210, 220 |
| Below fall line | ANACO, OCCOQ, POTOM |
| Rappahannock | |
| Above fall line | 230 |
| Below fall line | GREAT, RAPPA, COAST 8 |
| York | |
| Above fall line | 235, 240, 250, 260 |
| Below fall line | YORK |
| Piankatank - Mobjack Bay | PIANK |
| James | |
| Above fall line | 270, 280, 290, 300, 310, 320 |
| Below fall line | CHICK, ELIZA. NANSE, JAMES, COAST 9 |

TABLE 15. LAND USE IN THE CHESAPEAKE BAY BASIN, 1980, BY MAJOR RIVER BASIN

| | | NVPDC/Landsat Interpretation | Census of AG/ U.S. Forest Serv. |
|---|---|---|---|
| Susquehanna | | | |
| | Cropland | 18.3 | 18.1 |
| | Pasture | 17.5 | 6.4 |
| | Forest | 61.8 | 61.8 |
| | Urban & Other | 2.4 | 13.7 |
| Eastern Shore | | | |
| | Cropland | 40.8 | 31.4 |
| | Pasture | 7.5 | 2.0 |
| | Forest | 50.2 | 36.5 |
| | Urban & Other | 1.5 | 30.1 |
| West Chesapeake | | | |
| | Cropland | 23.0 | 13.7 |
| | Pasture | 19.3 | 5.4 |
| | Forest | 45.2 | 33.1 |
| | Urban & Other | 12.5 | 47.8 |
| Patuxent | | | |
| | Cropland | 20.6 | 15.1 |
| | Pasture | 20.7 | 6.0 |
| | Forest | 53.1 | 43.5 |
| | Urban & Other | 5.6 | 35.4 |
| Potomac | | | |
| | Cropland | 16.1 | 16.1 |
| | Pasture | 18.2 | 16.2 |
| | Forest | 61.6 | 56.0 |
| | Urban & Other | 4.16 | 11.7 |
| Rappahannock | | | |
| | Cropland | 15.5 | 17.0 |
| | Pasture | 19.6 | 16.3 |
| | Forest | 64.3 | 59.0 |
| | Urban & Other | 0.6 | 7.7 |
| York | | | |
| | Cropland | 16.6 | 11.6 |
| | Pasture | 13.1 | 6.2 |
| | Forest | 70.6 | 70.6 |
| | Urban & Other | 0.2 | 11.6 |
| James | | | |
| | Cropland | 10.5 | 8.2 |
| | Pasture | 13.7 | 12.3 |
| | Forest | 72.6 | 71.8 |
| | Urban & Other | 3.2 | 7.7 |
| Total | | | |
| | Cropland | 17.9 | 16.5 |
| | Pasture | 16.5 | 9.7 |
| | Forest | 62.6 | 59.4 |
| | Urban & Other | 3.0 | 14.4 |

TABLE 16. PERCENT BREAKDOWN OF CROPPING PRACTICES BY COUNTY IN THE PATUXENT RIVER BASIN

| | CBP/SCD | SCS | CES | Average |
|---|---|---|---|---|
| **Anne Arundel** | | | | |
| Conventional | 40 | 60 | 40 | 47 |
| Minimum | 60 | 30 | 40 | 43 |
| No-till | 0 | 10 | 20 | 10 |
| **Calvert** | | | | |
| Conventional | 34 | 70 | 75 | 60 |
| Minimum | 66 | 20 | 5 | 30 |
| No-till | 0 | 10 | 20 | 10 |
| **Charles** | | | | |
| Conventional | 37 | 50 | 30 | 39 |
| Minimum | 60 | 40 | 60 | 53 |
| No-till | 3 | 10 | 10 | 8 |
| **Howard** | | | | |
| Conventional | 32 | 15 | 15 | 21 |
| Minimum | 0 | 10 | 0 | 3 |
| No-till | 68 | 75 | 85 | 76 |
| **Montgomery** | | | | |
| Conventional | 0 | 10 | | |
| Minimum | 30 | 20 | | |
| No-till | 70 | 70 | | |
| **Prince George's** | | | | |
| Conventional | 20 | 60 | 70 | 50 |
| Minimum | 80 | 30 | 15 | 42 |
| No-till | 0 | 10 | 15 | 8 |
| **St. Mary's** | | | | |
| Conventional | 100 | 90 | 90 | 93 |
| Minimum | 0 | 0 | 0 | 0 |
| No-till | 0 | 10 | 10 | 7 |

CBP/SCD - Chesapeake Bay Program data from soil conservation district worksheets
SCS - Soil Conservation Service data
CES - Cooperative Extension Service data

# METHODOLOGIES FOR DETERMINING THE COSTS OF POINT SOURCE CONTROLS

## NUTRIENT REMOVAL AT POTWS

Nutrient removal costs for publicly-owned sewage treatment works (POTWs) will be based on the Computer Assisted Procedure for the Design and Evaluation of Wastewater Systems (CAPDET) Program. This program was developed by the EPA several years ago, in coordination with the U.S. Army Corps of Engineers, to assist in preliminary wastewater treatment plant design and cost-evaluation requirements. In July, 1980, the EPA Construction Grants Program issued Program Operations Memorandum #80-3 which accepted CAPDET for the cost evaluation requirements in Step 1 facilities planning. It was described as representing a "state-of-the-art" technique for preparations of facilities planning level cost estimates.

The scenarios that will be used for upgrading POTWs with nutrient removal are:

1) Total Phosphorus = 2 mg $L^{-1}$;
2) Total Phosphorus = 1 mg $L^{-1}$; and,
3) Total Nitrogen = 6 mg $L^{-1}$.

The costs will be presented in terms of: capital costs; operation and maintenance (O&M); total present worth; and cost per household.

Costs based on flows have been developed by running CAPDET at various flows from 1 million gallons per day (MGD) through 317 MGD. These values are then used to generate the costs for each POTW. Specifics on the CBP use of CAPDET follow:

1) To get upgrade costs, there were three CAPDET runs made for each flow. These were: secondary, secondary with phosphorus removal, and secondary with nitrogen removal. The costs for the secondary plant were subtracted from the others to give upgrade costs for nutrient removal.

2) Municipal upgrade costs for strategies applied to existing (1980) loads are based on 1980 operational flow and municipal upgrade costs for strategies applied to future (2000) loads are based on projected year 2000 operational flows. However, actual upgrading costs would be based on design flow because the entire facility must be retrofitted, not only the operation portion. But design flows have no bearing on nutrient loads and would prevent a dollar-per-pound removed cost analysis. For example, Plant A and Plant B each have design flows of 10.0 MGD. Plant A has an operational flow of 4 MGD and Plant B has an operational flow of 8 MGD. If upgrading costs are based on design flow, both plants would have the same retrofitting costs, yet the reduction in nutrient loadings achieved would be twice as great at Plant B than at Plant A. This would distort the dollar-per-pound-nutrient-removed-present-value cost-calculation. Bay-wide, design flow is 30 percent greater than existing (1980) operational flow and implementation costs for the effluent limitation strategies can be

expected to increase proportionately. Future (2000) flows are projected to be seven percent greater than design capacity. This indicates that additional secondary treatment beyond existing design capacity will be required to accomodate future flows. The cost to provide the additional secondary treatment is not included in the future implementation costs of management strategies.

3) Household costs and O & M costs were estimated assuming Federal construction grant funding. The CAPDET program default value was changed from 75 to 55 percent to reflect the Federal grant participation for FY 1985 and beyond. An argument could be made that these costs should be developed without any allowance for Federal funding.

4) The CAPDET program uses four different cost indices to update costs (Engineering News Record (ENR), Marshall and Swift (M & S), Large City EPA, and Pipe Cost). The ENR and M & S indices were updated to March, 1982 costs in the EPA program. The other two were not being updated and are, therefore, using 1977 default values.

5) The phosphorus removal process in the CAPDET program consists of adding a chemical coagulation step which includes an upflow clarifier and a chemical (lime) feed system.

   a. The program was run using alum instead of lime and the capital costs were about 25 percent higher while the O & M costs were about the same. The CBP will still use lime in their cost analysis.

   b. CAPDET uses a filter press for sludge dewatering. Unfortunately, the costs for this unit process are developed using parametric equations (i.e., only variable is flow). Therefore, even though the phosphorus removal run shows a greater quantity of sludge produced when compared to the secondary plant, the costs for the filter press are the same. The capital and O & M costs will, therefore, be about 5 to 10 percent too low in the CBP program.

6) The nitrogen removal process consists of adding nitrification/denitrification to a secondary facility. The CBP selected the suspended growth nitrification/denitrification process.

## Methanol Cost Adjustment

a. The January 1981 CAPDET User's Manual shows a 1977 methanol cost of 15¢/lb (pp. 3 to 41), but lists 90¢/lb elsewhere (p. D-3);

b. an earlier User's Manual showed a 90¢/lb figure; and

c. the EPA Innovative/Alternative Technology Manual shows a September 1976 cost of 50¢/gallon.

The CBP has concluded that the CAPDET program is erroneously reading the unit cost input in terms of cents per gallon instead of cents per pound. Therefore, the Program divides by a 5.9 conversion factor in calculating methanol costs.

In addition, it was agreed to update the true methanol costs by the EPA's Methanol Index which resulted in the following:

$$15¢ \times \frac{9.44}{4.22} = 33.5¢/\text{lb} \text{ -- 1982 costs}$$

Then, accounting for the error in the CAPDET program -

$$33.5¢/\text{lb} \times 5.9 = \$1.98/\text{lb}.$$

The CBP used the final figure as the input to the CAPDET program to get an answer that will be based on the 33.5¢/lb figure. These changes result in an annual methanol cost of 117,959 dollars for 1 MGD plant as opposed to the original 12,592 dollars. This increases the total O & M figure CAPDET was using by 37 percent for the 1 MGD plant.

## SECTION 4

# DESCRIPTION OF CHESAPEAKE BASIN MODEL

The estimates of nutrient loadings from the Bay's tributaries are based on results from a set of basin-wide computer models developed for the Chesapeake Bay Program. The CBP basin-wide watershed model simulates stream flows and the transport of point and nonpoint pollution loadings (such as sewage treatement plant discharge and cropland runoff) from river basins and coastal watersheds to the Bay and its tidal tributaries. The model routes these loads of nutrients and other substances down the tributaries to the Bay, accounting for degradation of the pollutants along the way. It is a lumped-parameter, continuous-simulation model in that the model continuously calculates water quality processes throughout the simulation period, using data that has been generalized for specific regions. Comprised of three sub-models [hydrologic (rainfall), nonpoint runoff, and tributary routing], the basin model calculates many processes, including the following: infiltration rates, soil moisture storage capacities, monthly variations in pollutant loading factors (such as fertilizer applications), water temperature changes, dissolved oxygen, sediment releases, and nutrient cycling and conversions.

## HYDROLOGIC SUB-MODEL

This model is based upon a modified version of the Stanford Watershed Model. It calculates the amount of rainfall converted to runoff, a continuous record of soil moisture during and after rainstorms, and sub-surface recharge of stream channels. Hydrologic simulations were run using continuous hourly rainfall records for wet, dry, and average years. During storm periods, rainfall is distributed among surface runoff and soil moisture storage based upon infiltration rates and soil-moisture storage capacities for upper and lower zones of soil profiles. Between storms, water storage in the soil is reduced by evapotranspiration and stream recharge, thereby freeing up soil-moisture storage capacity for the next storm. The model's infiltration rates are based on sub-basin soil factors such as hydrologic soil group, permeability, total water holding capacity, and depth to restrictive layer. Both the infiltration rate and soil moisture storage capacities are estimated from sub-basin data and refined by calibrating the model with observed stream-flow records. Parameters governing stream recharge from ground water are estimated from analyses of observed hydrographs and refined during calibration.

## NONPOINT POLLUTION LOADING SUB-MODEL

This model is a slightly modified version of the U.S. EPA's NPS Model (U.S. EPA 1976). It runs on rainfall intensity records and on the hydrologic sub-model's output of surface runoff and sub-surface flow records.

For cropland, the model assumes that sediment generation and washoff (i.e., soil loss) are the driving forces for loadings of all pollutants. Cropland loadings of sediment, which are calculated from rainfall records, are assigned sediment "potency factors" (i.e., ratio of pollutant mass to sediment mass) to calculate loadings of other pollutants. The representation of cropland areas is enhanced by several model features, such as the capability to assign monthly vegetative cover percentages that represent seasonal variations in exposed ground cover resulting from crop growth and harvest, and the capability to simulate soil disturbance on user-specified dates to account for tillage practices. For urban and pasture land-uses, nonpoint pollution wash-off algorithms relate the wash-off of accumulated pollutant loads to the simulated runoff rate in each time-step. Accumulated pollutant loads at the start of a rainstorm are calculated from the "daily pollutant accumulation rates" (lbs/ac/day) assigned to each land-use classification to represent the buildup of pollutants on the land surface and in the atmosphere (i.e., air pollution between rainstorms). For the forest-land category, pollutant loading calculations are based upon soil loss and potency factors as well as daily pollutant accumulations, with the former more prominent during periods of low leaf cover (i.e., fall and winter) and the latter more prominent during periods of high leaf cover (i.e., spring and summer).

Nonpoint pollution loading factors, such as sediment potency factors and daily pollutant accumulation rates, have been developed for the Chesapeake Bay basin from model calibration studies with CBP test watershed data and with several other monitoring studies (see Chesapeake Bay Basin Model Final Report). Eleven of the 27 CBP test watershed sites used to calibrate this sub-model are described in Table 17 and shown on Figure 36. The model has the capability to use monthly variations in pollutant loading factors. This feature permits a representation of variations in the pollutant loading potential of cropland areas due to such factors as fertilizer/manure applications, crop growth, crop harvest, etc. Sub-surface flow loadings based upon user-specified concentrations are added to hourly runoff pollution loadings and delivered to the outlet of each sub-basin.

## RECEIVING WATER SUB-MODEL

The hydrologic and nonpoint pollution loading sub-models are used to calculate hourly runoff, sub-surface flow, and pollutant loadings delivered to stream channel or reservoir by the tributary sub-basin. The receiving water sub-model combines the hourly stream-flow and pollutant loadings from the sub-basin models with daily point source loadings (see methodology to estimate point source loadings, below), subtracts out water supply diversions, and calculates daily pollutant transport and concentrations throughout the stream and reservoir system.

While all pollutant loading calculations in the nonpoint pollution loading sub-model assume no pollutant decay or transformation, the receiving water model simulates the major physical, chemical, and biological processes that change the magnitude and form of pollutants being transported downstream. The one-dimensional receiving water model is operated on an hourly computation interval with the stream-flow and pollutant loading records produced by the hydrologic and nonpoint pollution loading sub-models as well as daily records of solar radiation, cloud cover, maximum/minimum daily air temperature, dewpoint temperature, average wind velocity, and precipitation/evaporation. Stream-flow transport is handled with a form of kinematic wave routing, while pollutant transport out of a given channel reach into a downstream channel reach is based upon advection (i.e., transport of pollutant by movement of the parcel of water

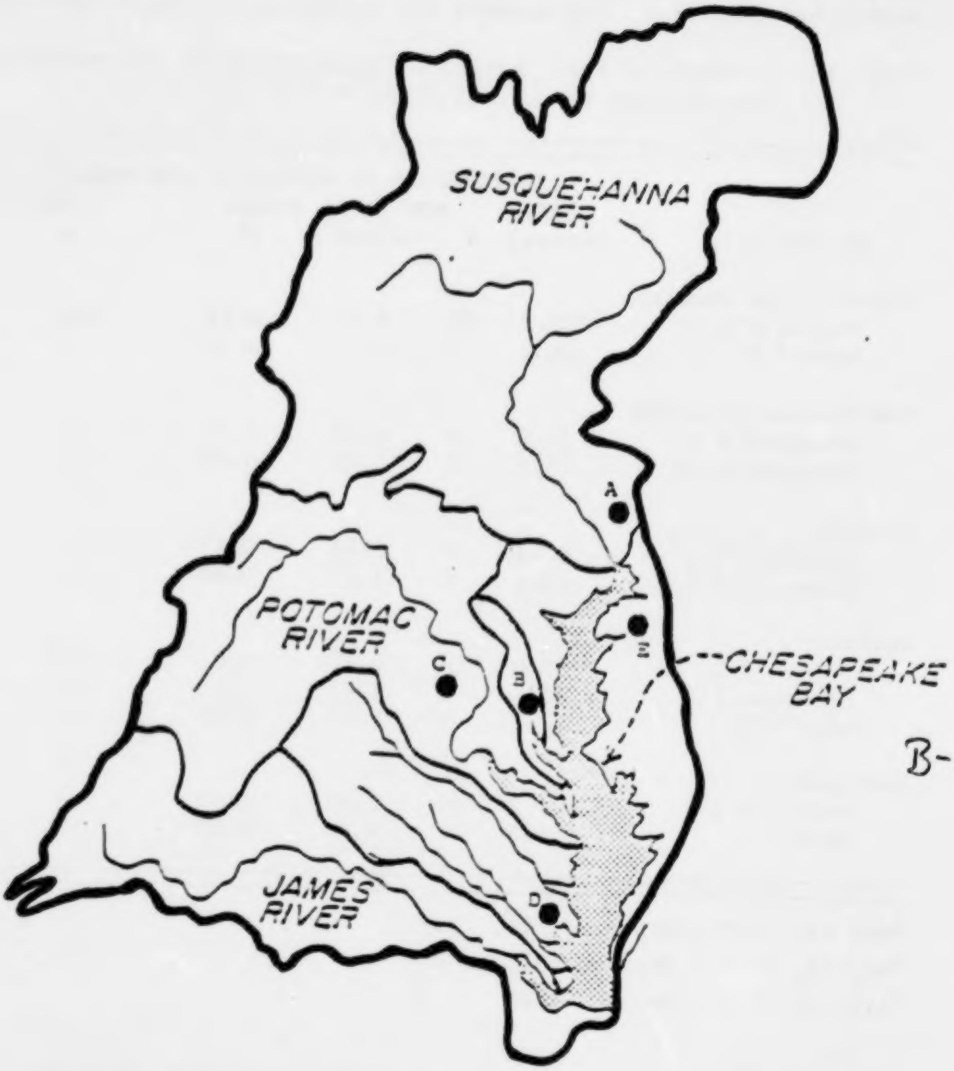


Figure 36. Location of EPA/CBP test watershed study sites: Pequea Creek (A), Patuxent River (B), Occoquan River (C), Ware River (D), and Chester River (E)

containing it). Because the travel time through any reach is significantly greater than the one-hour computational interval, plug-flow conditions and negligible dispersion are assumed for pollutant transport calculations.

TABLE 17. SUMMARY OF TEST WATERSHED CHARACTERISTICS AND HYDROLOGY CALIBRATION RESULTS (1.00 ha = 2.47 ac).

| | | REGRESSIONS OF SIMULATED AND OBSERVED FLOW VOLUMES | | | | | |
|---|---|---|---|---|---|---|---|
| | | MONITORED STORMS | | | DAILY STREAM-FLOWS | | |
| LAND USE/SITE | AREA (acres) | N | Slope | $R^2$ | N | Slope | $R^2$ |
| High-tillage cropland | | | | | | | |
| Pequea # 3 | 115.2 | 15 | 0.76 | 0.88 | 492[a] | 0.98 | 0.70 |
| Ware # 7 | 16.2 | 7 | 0.72 | 0.99 | -- | -- | -- |
| Low-Tillage cropland | | | | | | | |
| Occoquan # 2 | 26.6 | 8 | 0.98 | 0.98 | -- | -- | -- |
| Occoquan # 10 | 25.8 | 7 | 1.03 | 0.99 | -- | -- | -- |
| Pasture | | | | | | | |
| Occoquan # 1 | 31.3 | 5 | 0.81 | 0.95 | -- | -- | -- |
| Occoquan # 5 | 18.8 | 5 | 1.07 | 0.90 | -- | -- | -- |
| Forest | | | | | | | |
| Pequea # 2 | 128.0 | 18 | 0.70 | 0.62 | 222[b] | 0.7 | 0.79 |
| Occoquan # 9 | 75.8 | 7 | 1.11 | 0.95 | -- | -- | -- |
| Ware # 8 | 17.4 | 9 | 1.15 | 0.97 | -- | -- | -- |
| Residential | | | | | | | |
| Pequea # 4 | 147.2 | 26 | 0.86 | 0.98 | 374[c] | 0.96 | 0.84 |
| Ware # 5 | 6.2 | 17 | 0.80 | 0.92 | -- | -- | -- |

[a] May 23, 1979 - September 26, 1980

[b] May 23, 1979 - December 31, 1979

[c] May 23, 1979 - May 31, 1980

These models were verified against water quality monitoring data collected by the U.S. Geological Survey at the major points of freshwater flow into the Chesapeake (i.e., the fall lines of the James, Potomac, and Susquehanna Rivers). The stream-flows were calibrated and verified at all USGS stations from 1966 to 1978; then, water quality concentrations were calibrated from 1974 to 1975 and verified from 1976 to 1978 at USGS water quality guages throughout the basin. As a final check, the regression models developed from the two years of fall line monitoring by USGS were used with simulated flows from 1974 to 1978 to check loads of pollutants.

Following the calibration and verification process, the models were used for production runs to assess water quality impacts and management options. A number of techniques were used to estimate the relative contributions of point and nonpoint sources to the fall-line loadings (see Chesapeake Bay Basin Model Final Report for more detail). Initial production runs described existing (1980) and future (2000) conditions in the Bay. The model also helped to identify the sources contributing to water quality problem areas. In addition to these baseline production runs, the effects of different point and nonpoint control strategies on Bay water quality were tested. As a tool, water quality managers will be able to use and refine the Chesapeake Bay mathematical model to develop alternatives for more effective control policies for now and for the future.

## SECTION 5

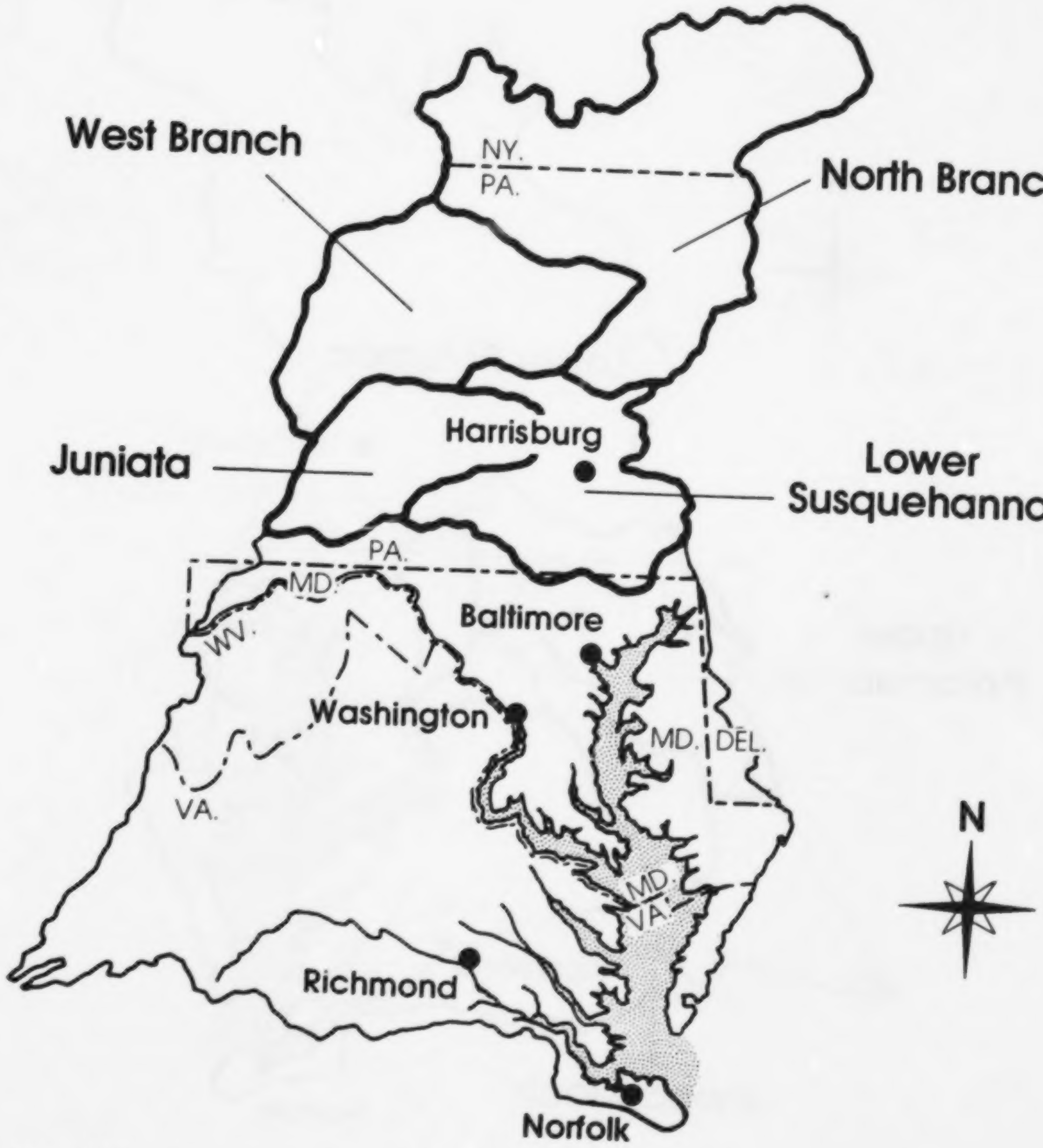
# SUMMARY OF MODELING RESULTS FOR EXISTING CONDITIONS

Existing (1980) nutrient loads to the fall line were simulated based on 1980 point source discharges, 1980 land use, and average year rainfall conditions. Loadings from individual sub-basins within a major drainage area can help to identify critical areas which contribute significant portions of the fall line nutrient load. Figures 37, 38, and 39 delimit sub-basins above the fall line within the Susquehanna, Potomac, and James River basins. Tables 18, 19, and 20 accompany these figures and provide detailed information on nutrient loadings from within each sub-basin. Each table is divided into (a) nonpoint and (b) point sources and contains five columns:

- Column A identifies the above the fall line sub-basins;
- Column B quantifies the percent of the area above the fall line that is within the sub-basin;
- Column C presents the percent of washed-off nonpoint or point source discharged load that is delivered to the fall line;
- Column D presents the percent of the total nonpoint or point source fall line nutrient load coming from the sub-basin; and
- Column E presents the March to October nonpoint or point source nutrient loads.

Columns C, D, and E are divided into nitrogen and phosphorus fractions.

An illustration of how to use the Figures and Tables may be helpful. For example, Figure 37 illustrates that, above the fall line, the Susquehanna River drainage area can be divided into four parts; the lower Susquehanna, Juniata, West Branch, and North Branch. Table 18 a and b correspond to Figure 37. Table 18 a shows that the lower Susquehanna sub-basin (Column A) occupies 20 percent of the land area (Column B) and accounts for 41 percent of the phosphorus and 36 percent of the nitrogen (Column D) delivered by nonpoint sources to the fall line. In this case, 82 percent of the phosphorus and 99 percent of the nitrogen washed from nonpoint sources in the lower Susquehanna River is delivered to the fall line (Column C). Column E is the March to October nonpoint loadings expressed in pounds. Table 17b provides similar information for point source loads. Tables 19 a and b correspond to Figure 38 for the Potomac River and Tables 20 a and b to Figure 39 for the James River.



Susquehanna River Sub Basins above the Fall Line

Figure 37. Susquehanna River drainage basin and sub-basins above the fall line

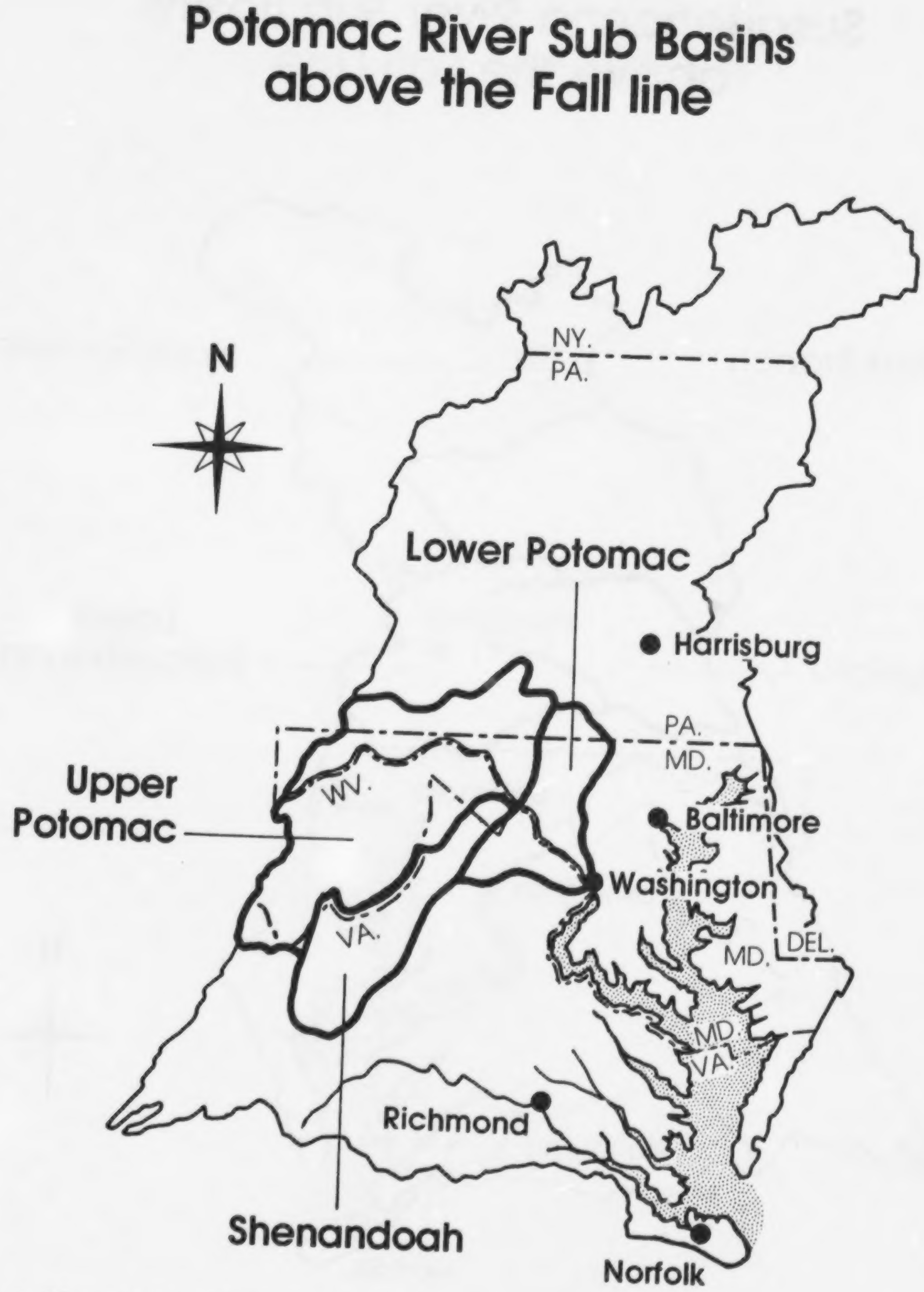


Figure 38. Potomac River drainage basin and sub-basins above the fall line

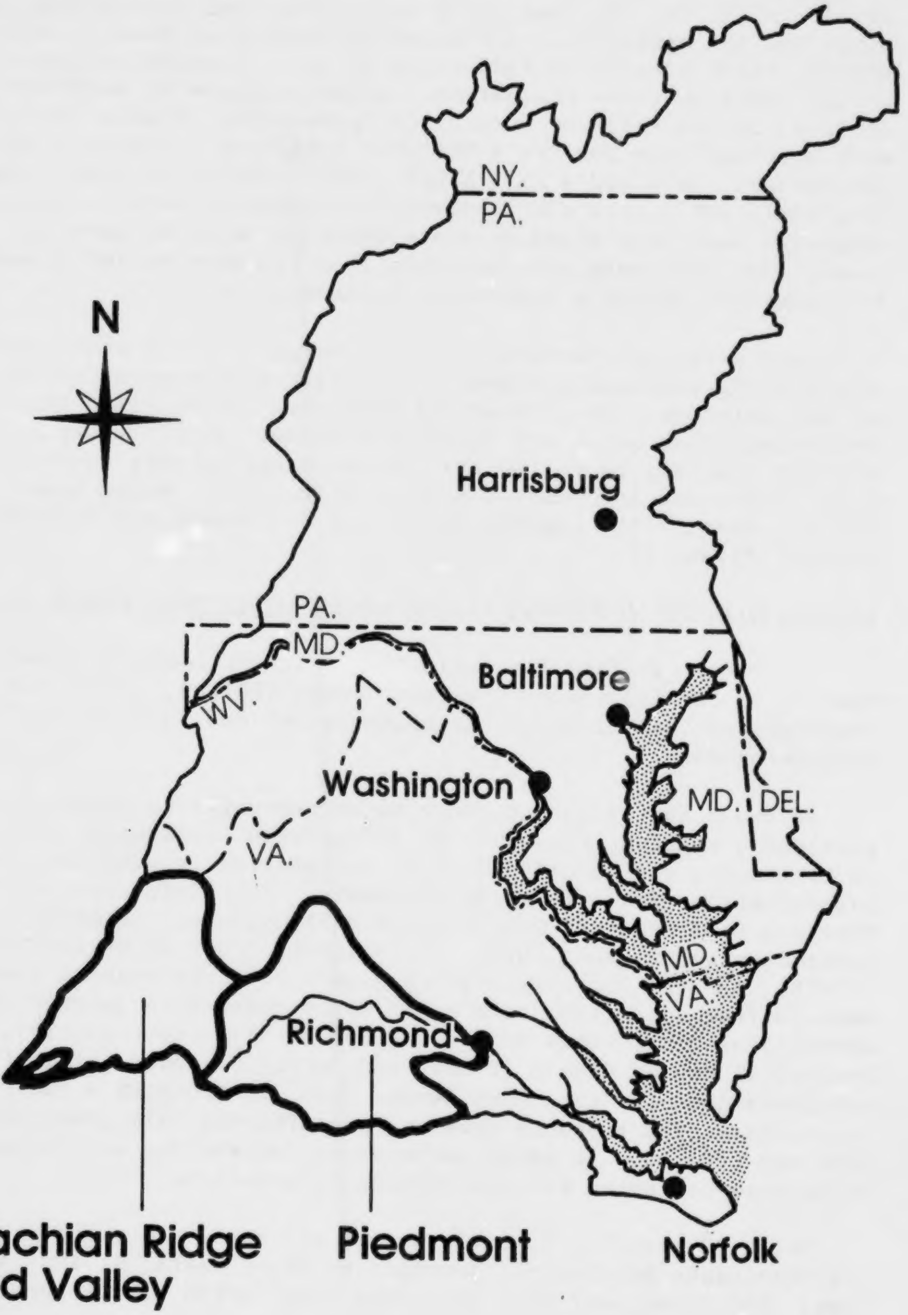

James River Sub Basins above the Fall Line

Figure 39. James River drainage basin and sub-basins above the fall line

## SECTION 6

# METHODOLOGIES FOR ESTIMATING POINT SOURCE NUTRIENT LOADS AND POINT SOURCE INVENTORY DATA

## ESTIMATION OF NUTRIENT LOADS FROM INDUSTRIAL POINT SOURCES

Types of industrial activity with the potential to discharge the nutrients TP, TN, TKN, and $NH_{3,4}$ were identified through discussion with state and EPA officials. The Standard Industrial Classification (SIC) system, which classifies industries by their economic activity, was used to assign codes to these discharges. Concentrations of nutrients expected to be found in the effluent from dischargers within a selected SIC category were obtained from the EPA's Effluent Guideline Division (EGD) and the literature. Maryland's 1979 NPDES permit compliance monitoring data and Virginia's DMR's were also reviewed for observed nutrient data. Industrial discharge data were based on state DMR's or on NPDES permits. In some cases, flow data were not available from the sources and so were estimated from averages within a particular industrial activity.

State officials familiar with dischargers within their jurisdiction reviewed the loadings assigned to specific dischargers for reasonableness and completeness. These loadings were then incorporated into CBP estimates of loadings from point and nonpoint sources. An inventory of industrial nutrient dischargers to the Bay follows later in this section. Arranged by major basin, the information presented includes: major basin (location), facility name, NPDES number, state, and phosphorus and nitrogen load in lbs/day (Table 21).

## ESTIMATION OF NUTRIENT LOADS FROM MUNICIPAL POINT SOURCES

The basic strategy for estimating nutrient loads from municipal point sources or publicly-owned treatment works (POTWs), called for merging computerized data bases and accessing state and facility effluent monitoring data.

Although the merging of data bases generated an inventory of POTWs and provided a substantial amount of information concerning their flow, level of treatment, and location, it did not provide information concerning the concentration of nutrients in effluents. To obtain this information the Maryland Department of Health and Mental Hygiene, the Office of Environmental Programs (OEP), the Virginia State Water Control Board (VSWCB), and the Pennsylvania Department of Environmental Resources (DER) were contracted. Each state staff was requested to provide 1980 data on operational flow, total nitrogen (TN), total phosphorus (TP), five-day biological oxygen demand (BOD5), and total suspended solids (SED) concentrations for the POTWs larger than 0.5 MGD within their political boundaries. The response from state staffs was very good, and the CBP data base was updated. In cases where state information was incomplete, the POTWs were contacted for the missing information.

Table 22 provides an inventory of municipal treatment plants located in the Chesapeake Bay basin. Arranged by major basin, it indicates facility name, 1980 flow, year 2000 projected flow, NPDES permit number, type of treatment, and concentrations of nutrients (nitrogen and phosphorus), conventional pollutants (BOD5 and TSS), and total residual chlorine (TRC) obtained through this methodology. The values listed in Table 22 were then used to calculate the nutrient load from municipal point sources.

TABLE 18a. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENTS FROM NONPOINT SOURCES ABOVE THE FALL LINE IN THE SUSQUEHANNA RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| | | NONPOINT | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | | D | | E | |
| | Percentage of basin area | Percentage of washed load that is delivered to the fall Line | | Percentage of total NPS fall line load from indicated sub-basin | | Fall line nutrient load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| West Branch | 26 | 50 | 73 | 28 | 20 | 617,000 | 10,476,000 |
| North Branch | 42 | 27 | 61 | 27 | 33 | 595,000 | 17,285,000 |
| Juniata | 12 | 27 | 75 | 4 | 11 | 88,000 | 5,762,000 |
| Lower Susquehanna | 20 | 82 | 99 | 41 | 36 | 904,000 | 18,857,000 |
| TOTAL | 100 | 46 | 77 | 100 | 100 | 2,204,000 | 52,380,000 |

TABLE 18b. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENTS FROM POINT SOURCES ABOVE THE FALL LINE IN THE SUSQUEHANNA RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| | | POINT | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | | D | | E | |
| | Percentage of basin area | Percentage of discharge that is delivered to the fall line | | Percentage of point source fall line load from indicated sub-basin | | Fall line nutrient load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| West Branch | 26 | 11 | - | 5 | - | 35,000 | -- |
| North Branch | 42 | 11 | - | 33 | - | 230,000 | -- |
| Juniata | 12 | 16 | - | 5 | - | 35,000 | -- |
| Lower Susquehanna | 20 | 59 | - | 57 | - | 396,000 | -- |
| TOTAL | 100 | 22 | - | 100 | - | 696,000 | 5,820,000 |

TABLE 19a. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENTS FROM NONPOINT SOURCES ABOVE THE FALL LINE IN THE POTOMAC RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| | | NONPOINT | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | | D | | E | |
| | Percentage of basin area | Percentage of washed load that is delivered to the fall line | | Percentage NPS fall line load from indicated sub-basin | | Fall line nutrient load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| Upper Potomac | 57 | 65 | 86 | 45 | 55 | 327,000 | 8,217,000 |
| Shenandoah | 26 | 65 | 80 | 25 | 25 | 181,000 | 3,735,000 |
| Monocacy | 9 | 79 | 86 | 12 | 11 | 87,000 | 1,643,000 |
| Lower Potomac | 8 | 85 | 86 | 18 | 9 | 131,000 | 1,345,000 |
| TOTAL | 100 | 69 | 84 | 100 | 100 | 726,000 | 14,940,000 |

TABLE 19b. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENTS FROM POINT SOURCES ABOVE THE FALL LINE IN THE POTOMAC RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| | | POINT | | | | | |
|---|---|---|---|---|---|---|---|
| A | B | C | | D | | E | |
| | Percentage of basin area | Percentage of discharge that is delivered to the fall line | | Percentage of point source fall line load from indicated sub-basin | | Fall line NPS load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| Upper Potomac | 57 | 14 | - | 31 | - | 40,000 | -- |
| Shenandoah | 26 | 8 | - | 19 | - | 24,000 | -- |
| Monocacy | 9 | 32 | - | 39 | - | 50,000 | -- |
| Lower Potomac | 8 | 68 | - | 11 | - | 14,000 | -- |
| TOTAL | 100 | 17 | - | 100 | | 128,000 | -- |

TABLE 20a. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENTS FROM NONPOINT SOURCES ABOVE THE FALL LINE IN THE JAMES RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| A | B | NONPOINT | | | | | |
|---|---|---|---|---|---|---|---|
| | | C | | D | | E | |
| | Percentage of basin area | Percentage of washed load that is delivered to the fall line | | Percentage of NPS load from indicated sub-basin | | Fall line nutrient load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| Appalachian Ridge & Valley | 48 | 57 | 66 | 46 | 50 | 226,000 | 2,310,000 |
| Piedmont | 52 | 76 | 81 | 54 | 50 | 266,000 | 2,310,000 |
| TOTAL | 100 | 66 | 73 | 100 | 100 | 492,000 | 4,620,000 |

TABLE 20b. SIMULATED LOADS (LBS), SOURCES, AND DELIVERY (PERCENTAGE) OF NUTRIENT FROM POINT SOURCES ABOVE THE FALL LINE IN THE JAMES RIVER BASIN IN AN AVERAGE YEAR (MARCH TO OCTOBER)

| A | B | POINT | | | | | |
|---|---|---|---|---|---|---|---|
| | | C | | D | | E | |
| | Percentage of basin area | Percentage of discharge that is delivered to the fall line | | Percentage of point source fall line load from indicated sub-basin | | Fall line nutrient load (lbs, Mar-Oct) | |
| Sub-basin | | Total P | Total N | Total P | Total N | Total P | Total N |
| Appalachian Ridge & Valley | 48 | 30 | - | 10 | - | 28,000 | -- |
| Piedmont | 52 | 69 | - | 90 | - | 249,000 | -- |
| TOTAL | 100 | 61 | - | 100 | - | 277,000 | 457,000 |

## SECTION 7

# PHOSPHORUS BAN NUTRIENT LOAD REDUCTIONS AND COSTS

## INTRODUCTION

The phosphorus in municipal influent to POTWs occurs in several forms, including phosphorus in suspended solids, polyphosphates, and orthophosphates. Human excreta and food solids contribute the insoluble suspended solid fraction and synthetic detergents contribute the soluble polyphosphates. The soluble orthophosphates are mainly the hydrolysis products of detergent polyphosphates, human wastes, and solids containing phosphorus. Most of the insoluble forms of phosphorus can be removed by conventional primary or secondary treatment processes. The soluble fractions, however, are only partially removed and may be discharged into receiving waters where they are available to support eutrophication unless specific control technology is provided.

Phosphorus is used in modern synthetic detergents to bring about conditions in the wash water which permit cleaning agents to work much more effectively. Currently, the average phosphorus content in detergents is about 6 percent. Prior to major reformulation efforts by the detergent industry in the 1970's, the phosphorus content in detergents varied between 9 and 12 percent (Folsom-Oliver 1980). Limiting the concentration of phosphorus to 0.5 percent by weight in detergent formulations (P ban) will lower the amount of soluble polyphosphates contributed by synthetic detergents to municipal influent wastewater, lower the effluent phosphorus concentration and, in POTWs with phosphorus control, reduct sludge disposal and chemical treatment costs. These benefits realized at POTWs must be measured against costs borne by consumers attempting to maintain the same level of cleaning with detergents containing phosphorus substitutes.

## ESTIMATION OF CHANGE IN INFLUENT/EFFLUENT PHOSPHORUS CONCENTRATION

Influent phosphorus concentrations for municipal treatment plants in the Hampton Roads Sanitation District and Metropolitan Washington, DC averaged 9.1 mg $L^{-1}$ and 8.3 mg $L^{-1}$, respectively. For the purpose of this analysis, the average of these two values, 8.7 mg $L^{-1}$ will be considered to be the average influent phosphorus for treatment plants in the Chesapeake Bay area. The Soap and Detergent Association (SDA) has estimated the per capita consumption of detergent phosphorus to be 0.4 kg/capita/year. Based on this per capita consumption of phosphorus (MASS) and water consumption of 133 gallons per capita per day (VOLUME), 2.2 mg $L^{-1}$, or 25 percent, (Concentration = MASS/VOLUME) of the total influent phosphorus concentration is attributable to synthetic detergents. The CBP estimates the 25 percent expected reduction in influent phosphorus will translate into a 30 percent reduction in effluent phosphorus concentration. This estimate is based on observations at Blue Plains during the 1969 to 1979 time frame which indicated that biological incorporation of phosphorus through the treatment process will remain the same before and after a ban (Jones 1982).

## SAVINGS AT POTWS

For plants already employing phosphorus control technology, a phosphorus ban would have a minimal impact on phosphorus loadings. However, it could be expected to lower annual chemical treatment and sludge disposal costs.

Barth (1978) estimated that a 25 percent reduction in O & M costs would be realized if influent phosphorus concentrations were reduced 50 percent. Applying the ratio between influent phosphorus concentrations and O & M savings, it is estimated that O & M costs for POTWs with phosphorus control in the Chesapeake Bay drainage area would be reduced 15 percent. Jones (1981) estimated annual O & M savings of 12,000 dollars per million gallons treated at POTWs with phosphorus removal as a result of a phosphorus ban. When Jones' estimates of savings are compared to total O & M costs for phosphorus control at a 1 and 317 MGD treatment plant, they represent 9 and 23 percent, respectively, of O & M costs for phosphorus removal. Based on these figures, the CBP estimated that a 15 percent reduction in phosphorus O & M removal costs would be realized with a phosphorus ban.

## CONSUMER COSTS

According to a report prepared for the SDA (Folsom-Oliver 1980), household cleaning costs will increase between 4.29 and 11.10 dollars per household (2.7 persons) per year if a phosphorus ban is imposed. The increased consumer costs arise from increased use of hot water, laundry bleaches, and softeners to achieve similar cleaning/washing results. The CBP used the average of this range of values (7.70 dollars) in calculating annual consumer costs for residents of the Chesapeake Bay watershed.

TABLE 21. INVENTORY OF INDUSTRIAL NUTRIENT DISCHARGERS TO CHESAPEAKE BAY, BY MAJOR BASIN

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | NUTRIENT LOAD (LBS/DAY) | |
|---|---|---|---|---|---|
| | | | | PHOSPHORUS | NITROGEN |
| PATUXEN | FIRST MD UTILITIES | 22781 | MD | 9.1 | . |
| PATUXEN | JOHNS HOPKINS APPLIED PHYSICS LAB | 2342 | MD | 9.2 | 24.6 |
| PATUXEN | MD AND VA MILK PRODUCERS | 469 | MD | 47.3 | 44.5 |
| PATUXEN | NEVAMAR CORP | 2003 | MD | . | 32.1 |
| POTOMAC | ACME MARKETS ABBATTOIR | 10669 | PA | 11.7 | 5.0 |
| POTOMAC | AVTEX FIBERS INC, FRONT ROYAL | 2208 | VA | . | 472.0 |
| POTOMAC | BEVANS OYSTER CO. | 2097 | VA | 1.4 | 11.2 |
| POTOMAC | CROMPTON CO., INC.-SHENANDOAH PLANT | 1999 | VA | . | 45.0 |
| POTOMAC | E.I. DUPONT DE NEMOURS&CO-WAYNESBORO | 2160 | VA | . | 347.2 |
| POTOMAC | GENERAL ELECTRIC CO - WAYNESBORO | 2402 | VA | 5.4 | . |
| POTOMAC | MERCK & CO., INC. | 2178 | VA | 710.0 | 1744.0 |
| POTOMAC | ROCCO FARM FOODS, INC | 1907 | VA | 25.6 | 145.6 |
| POTOMAC | ROCKINGHAM POULTRY - ALMA PLANT | 1961 | VA | 9.6 | 182.0 |
| POTOMAC | ROCKINGHAM POULTRY-BROADWAY PLT | 2011 | VA | 13.7 | 77.8 |
| POTOMAC | SHEN-VALLEY MEAT PACKERS, INC. | 1791 | VA | 27.6 | 9.7 |
| POTOMAC | VIRGINIA OAK TANNERY, LURAY | 2267 | VA | . | 15.0 |
| POTOMAC | W C BYRON & SONS INC | 53431 | MD | . | 74.5 |
| POTOMAC | WAMPLER FOODS, INC. | 2313 | VA | 4.3 | 24.4 |
| POTOMAC | WD BYRON AND SONS INC | 434 | MD | . | 496.8 |
| RAPP | BARNHARDT FARMS-MAIN, URBANNA | 3123 | VA | . | 96.0 |
| RAPP | STANDARD PRODUCTS CO. INC. | 3204 | VA | 167.3 | 200.3 |
| SUSQUHANNA | AGWAY PETROLEUM CORPORATION | 10906 | PA | . | 47.2 |
| SUSQUHANNA | ALLEN CLARK INC | 14524 | PA | 12.8 | 72.8 |
| SUSQUHANNA | AVTEX FIBERS INC. | 8176 | PA | . | 35.4 |
| SUSQUHANNA | BETHLEHEM STEEL CORP LEBANON | 8290 | PA | . | 43.0 |
| SUSQUHANNA | BETHLEHEM STEEL CORP WMSPORT | 8575 | PA | . | 15.4 |
| SUSQUHANNA | BETHLEHEM STEEL-STEELTON | 8303 | PA | . | 267.6 |
| SUSQUHANNA | CLARK PACKING CO INC | 10596 | PA | 33.4 | 14.4 |
| SUSQUHANNA | EBERLE TANNING CO-WESTFIELD | 8800 | PA | . | 129.2 |
| SUSQUHANNA | EMPIRE KOSHER POULTRY | 7552 | PA | 37.8 | 214.7 |
| SUSQUHANNA | EMPIRE KOSHER POULTRY, INC. | 10191 | PA | 1.9 | 10.9 |
| SUSQUHANNA | HARRISBURG STEEL CO | 8184 | PA | . | 49.6 |
| SUSQUHANNA | MANDATA POULTRY CO-HERNDON | 9474 | PA | 29.4 | 167.4 |
| SUSQUHANNA | STD STEEL TITANIUM METALS DIV | 9164 | PA | . | 97.8 |
| SUSQUHANNA | VICTOR F WEAVER INC | 35092 | PA | 89.6 | 509.5 |
| SUSQUHANNA | WESTOVER LEATHER CO | 7439 | PA | . | 844.6 |

(CONTINUED)

TABLE 21. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | NUTRIENT LOAD (LBS/DAY) PHOSPHORUS | NUTRIENT LOAD (LBS/DAY) NITROGEN |
|---|---|---|---|---|---|
| E SHORE | CONCORD FARMS, INC. | 1589 | MD | 22.4 | 127.4 |
| E SHORE | H.V. DREWER & SONS SEAFOOD | 6009 | VA | 7.6 | 59.5 |
| E SHORE | HOLLY FARMS POULTRY INC-TEMPERANCEVILLE | 4049 | VA | 53.8 | 305.7 |
| E SHORE | LANCE G. FISHER SEAFOOD CO, INC | 5321 | VA | 2.5 | 19.6 |
| E SHORE | MARYLAND CHICKEN PROCESSORS | 680 | MD | 12.8 | 72.8 |
| E SHORE | OLD SALT SEAFOOD CO.,INC. | 54551 | MD | 12.2 | 95.8 |
| E SHORE | SUDLERSVILLE FROZEN FOOD LOCKERS INC | 54933 | MD | 15.0 | 6.5 |
| E SHORE | W O WHITELEY AND SONS | 442 | MD | 79.6 | 7.5 |
| E SHORE | WACHSBERG PICKLE WORKS | 53601 | MD | 79.6 | 7.5 |
| JAMES | ALLIED CHEM CORP, HOPEWELL | 5291 | VA | 175.0 | 6005.0 |
| JAMES | ALLIED CHEMICAL CORP | 5312 | VA | 42.0 | 1467.0 |
| JAMES | BORDEN, INC - SMITH DOUGLASS DIV | 2941 | VA | . | 242.5 |
| JAMES | BURLINGTON INDUSTRIES INC | 4677 | VA | 167.0 | 68.0 |
| JAMES | CPC INTERNATIONAL, INC-BEST FOODS DIV | 3140 | VA | 289.0 | 27.3 |
| JAMES | DOW BADISCHE CO, WILLIAMSBURG | 3654 | VA | . | 65.5 |
| JAMES | E I DUPONT DE NEMOURS & CO | 4669 | VA | 169.0 | 3725.0 |
| JAMES | FIRESTONE SYNTHETIC, HOPEWELL | 3298 | VA | . | 34.9 |
| JAMES | HAMPTON ROADS ENERGY COMPANY | 53171 | VA | . | 235.9 |
| JAMES | HOLLY FARMS POULTRY IND. INC. | 4031 | VA | 3.0 | 12.0 |
| JAMES | INTERCOASTAL STEEL CORP. | 61107 | VA | . | 34.9 |
| JAMES | ITT GWALTNEY, INC | 2844 | VA | 634.2 | 272.7 |
| JAMES | J.H. MILES & CO, INC | 3263 | VA | 27.8 | 217.6 |
| JAMES | MORTON FROZEN FOODS, INC. | 4626 | VA | 70.0 | 30.0 |
| JAMES | NAVY NORFOLK SHIPYARD | 5215 | VA | 29.2 | 96.0 |
| JAMES | NEWPORT NEWS SHIPBUILDING & DRY DOCK | 4804 | VA | 23.4 | 76.8 |
| JAMES | NORFOLK SHIPBUILDING & DRYDOCK CORP | 4383 | VA | 3.3 | 10.9 |
| JAMES | RAMSEY & KELLEY INC | 56413 | VA | . | 47.2 |
| JAMES | ROYSTER CO | 3174 | VA | 0.8 | 15.1 |
| JAMES | ROYSTER CO | 3174 | VA | 0.8 | 15.1 |
| JAMES | ROYSTER CO | 3174 | VA | 0.8 | 15.1 |
| JAMES | ROYSTER CO | 3174 | VA | 0.8 | 15.1 |
| JAMES | SMITHFIELD PACKING CO | 2879 | VA | 212.1 | 91.2 |
| JAMES | VIRGINIA CHEMICALS, INC. | 3387 | VA | 244.0 | . |
| JAMES | VIRGINIA PACKING CO. | 5207 | VA | 8.9 | 3.8 |
| JAMES | WEAVER FERTILIZER CO., INC. | 3875 | VA | . | 170.7 |

(CONTINUED)

TABLE 21. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | NUTRIENT LOAD (LBS/DAY) | |
|---|---|---|---|---|---|
| | | | | PHOSPHORUS | NITROGEN |
| W CHESAP | ALLIED CHEMICAL- BALTIMORE | 2186 | MD | 2.1 | 41.8 |
| W CHESAP | BETHLEHEM STEEL CORP BALTIMORE | 1198 | MD | 11.5 | 37.8 |
| W CHESAP | BETHLEHEM STEEL SPARROWS POINT | 1201 | MD | 1709.0 | 23046.0 |
| W CHESAP | CONTINENTAL OIL BALTO PETRO PL | 540 | MD | . | 101.0 |
| W CHESAP | EASTERN STAINLESS STEEL CO | 981 | MD | . | 41.9 |
| W CHESAP | FMC CORP INDUSTRIAL CHEM DIV | 299 | MD | 167.0 | 144.0 |
| W CHESAP | GLIDDEN DURKEE BROENING HWY | 1279 | MD | 30.5 | 39.0 |
| W CHESAP | M AND T CHEMICALS INC | 426 | MD | 0.8 | 15.1 |
| W CHESAP | MINEREC CORPORATION | 56332 | MD | . | 47.2 |
| W CHESAP | OLIN CORP CHEMICALS GROUP | 1015 | MD | 0.6 | 12.2 |
| W CHESAP | OLIN CORP CHEMICALS GROUP | 1015 | MD | 1.1 | 22.6 |
| W CHESAP | SCM CORP-ADRIAN JOYCE WORKS | 1261 | MD | 2.3 | 45.2 |
| W CHESAP | SCM CORP-ADRIAN JOYCE WORKS | 1261 | MD | 1.4 | 28.2 |
| W CHESAP | SCM CORPORATION-CHEMICAL/METALLURGIC.DIV | 57657 | MD | 0.8 | 15.1 |
| W CHESAP | WR GRACE DAVISON CHEM DIV | 311 | MD | 2.3 | 2203.0 |
| YORK | AMOCO OIL CO | 3018 | VA | 8.0 | 50.0 |
| YORK | CHESAPEAKE CORP | 3115 | VA | 198.0 | 689.0 |

TABLE 22. INVENTORY OF MUNICIPAL NUTRIENT DISCHARGERS TO CHESAPEAKE BAY, BY MAJOR BASIN

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCP POLICY | TREAT. | FLOW (MGD) | | EFFLUENT CONCENTRATION (MG/L) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1980 | 2000 | BOD5 | TSS | TP | TN | TRC |
| E SHORE | BRIDGEVILLE STP | 20249 | DE | | SECONDARY | 0.43 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | CAMBRIDGE WWTF | 21636 | MD | | SECONDARY | 4.40 | 8.1 | 6. | 7.9 | 4.6 | 11.9 | 0.89 |
| E SHORE | CENTREVILLE WWT | 20834 | MD | | SECONDARY | 0.22 | 0.3 | 30. | 30.0 | 4.0 | 12.0 | 2.21 |
| E SHORE | CHARLESTOWN WWT | 21067 | MD | | SECONDARY | 0.18 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | CHESAPEAKE STP | 20397 | MD | | PRIMARY | 0.12 | 0.3 | 140. | 140.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | CHESTERTOWN WWT | 20010 | MD | | SECONDARY | 0.38 | 0.9 | 17. | 80.5 | 8.5 | 19.5 | 2.73 |
| E SHORE | CRISFIELD WWTP | 20001 | MD | | SECONDARY | 0.76 | 1.0 | 20. | 37.1 | 4.4 | 6.9 | 2.54 |
| E SHORE | DELMAR SEW SYS | 20532 | MD | | SECONDARY | 0.50 | 0.6 | 33. | 40.0 | 8.0 | 18.5 | 2.70 |
| E SHORE | DENTON WWTP | 20494 | MD | | SECONDARY | 0.27 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 1.33 |
| E SHORE | DOR CO SAN DIST | 22667 | MD | | SECONDARY | 0.21 | 0.4 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | EASTON WSL | 20273 | MD | | SECONDARY | 1.80 | 2.0 | 30. | 90.0 | 8.6 | 10.2 | 1.64 |
| E SHORE | ELKTON WWTP | 20681 | MD | YES | SECONDARY | 0.80 | 2.7 | 79. | 76.5 | 7.0 | 24.8 | 3.54 |
| E SHORE | FEDERALSBURG WW | 20249 | MD | | PRIMARY | 0.60 | 0.8 | 65. | 115.0 | 8.0 | 18.5 | 1.13 |
| E SHORE | FRUITLAND WWTP | 52990 | MD | | SECONDARY | 0.28 | 0.5 | 65. | 115.0 | 8.5 | 18.5 | 3.10 |
| E SHORE | GEORGETOWN STP | 20257 | DE | | SECONDARY | 0.31 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | GREENSBORO W W | 20290 | MD | | SECONDARY | 0.16 | 0.7 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | HOLLY HALL TERR | 51934 | MD | | SECONDARY | 0.14 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | HURLOCK WWTF | 22730 | MD | | SECONDARY | 1.10 | 1.5 | 20. | 67.5 | 3.5 | 13.5 | 1.61 |
| E SHORE | LAUREL SEWERAGE | 20125 | DE | | SECONDARY | 0.58 | 0.9 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | ONANCOCK STP | 21253 | VA | | PHOS REM | 0.13 | 0.4 | 1. | 1.7 | 1.5 | 15.0 | 2.00 |
| E SHORE | POCOMOKE CITY W | 22551 | MD | | SECONDARY | 1.10 | 2.0 | 27. | 60.4 | 8.0 | 18.5 | 3.51 |
| E SHORE | PRINCESS ANNE W | 20656 | MD | | SECONDARY | 0.27 | 0.7 | 30. | 30.0 | 7.9 | 20.6 | 4.39 |
| E SHORE | ROCK HALL WWTP | 20303 | MD | | SECONDARY | 0.18 | 0.2 | 30. | 90.0 | 8.0 | 18.5 | 4.29 |
| E SHORE | SAINT MICHAELS | 20826 | MD | | SECONDARY | 0.14 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | SALISBURY WWTF | 21571 | MD | | SECONDARY | 3.50 | 5.8 | 38. | 17.3 | 5.8 | 24.6 | 2.95 |
| E SHORE | SEAFORD STP | 20265 | DE | | SECONDARY | 0.64 | 0.9 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | SHARPTOWN WWTP | 52175 | MD | | SECONDARY | 0.11 | 0.1 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| E SHORE | SNOW HILL WWTP | 22764 | MD | | PRIMARY | 0.33 | 0.5 | 70. | 70.0 | 5.8 | 18.5 | 2.00 |
| E SHORE | TWIN CITIES | 23221 | MD | | SECONDARY | 0.28 | 0.2 | 30. | 30.0 | 8.0 | 18.5 | 2.26 |
| JAMES | ARMY BASE W P C | 25208 | VA | | PRIMARY | 12.38 | 18.0 | 26. | 23.2 | 5.6 | 27.8 | 2.06 |
| JAMES | ASHTON CREEK LA | 21458 | VA | | PRIMARY | 0.23 | 0.0 | 65. | 115.0 | [illegible].5 | 18.5 | 2.00 |
| JAMES | BOAT HARBOR W P | 25283 | VA | | PRIMARY | 17.60 | 25.0 | 68. | 31.8 | 3.5 | 25.1 | 1.80 |
| JAMES | BUENA VISTA STP | 20991 | VA | | PRIMARY | 1.32 | 2.0 | 145. | 52.1 | 9.5 | 20.8 | 2.00 |
| JAMES | CHESAPEAKE-ELIZ | 25275 | VA | | SECONDARY | 19.70 | 24.0 | 19. | 28.5 | 6.1 | 18.5 | 2.55 |
| JAMES | CHESTER LOGOON | 21466 | VA | | PRIMARY | 0.11 | 0.0 | 65. | 115.0 | 8.5 | 18.5 | 2.00 |
| JAMES | CLIFTON FORGE S | 22772 | VA | | SECONDARY | 0.72 | 2.0 | 26. | 18.2 | 8.0 | 18.5 | 2.00 |
| JAMES | COVINGTON STP | 25542 | VA | | PRIMARY | 1.60 | 3.0 | 59. | 27.5 | 9.5 | 20.8 | 2.00 |
| JAMES | DEEP CREEK LAGO | 21202 | VA | | PRIMARY | 1.02 | 0.0 | 106. | 41.6 | 9.5 | 20.8 | 2.02 |
| JAMES | FALLING CREEK S | 24996 | VA | | SECONDARY | 7.58 | 16.0 | 17. | 31.0 | 5.5 | 23.0 | 1.56 |

(CONTINUED)

TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCB POLICY | TREAT. | FLOW (MGD) |  | EFFLUENT CONCENTRATION (MG/L |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | 1980 | 2000 | BOD5 | TSS | TP | TN | TRC |
| JAMES | HOPEWELL STP | 25640 | VA |  | SECONDARY | 33.63 | 50.0 | 21. | 50.8 | 1.0 | 49.0 | 2.00 |
| JAMES | JAMES RIVER W P | 25241 | VA |  | SECONDARY | 13.70 | 15.0 | 3. | 10.6 | 7.4 | 11.7 | 2.03 |
| JAMES | LAMBERTS POINT | 25259 | VA |  | PRIMARY | 20.63 | 35.0 | 94. | 40.3 | 4.5 | 18.5 | 1.80 |
| JAMES | LEXINGTON STP | 20567 | VA |  | PHOS REM | 0.77 | 2.0 | 6. | 11.0 | 1.5 | 15.0 | 2.00 |
| JAMES | LYNCHBURG STP | 24970 | VA |  | SECONDARY | 11.55 | 15.0 | 14. | 11.8 | 8.0 | 18.5 | 1.97 |
| JAMES | MEADOW CREEK ST | 25500 | VA |  | SECONDARY | 3.26 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| JAMES | MOORES CREEK ST | 25518 | VA |  | SECONDARY | 2.60 | 15.0 | 14. | 15.8 | 8.0 | 18.5 | 2.00 |
| JAMES | PETERSBURG STP | 25437 | VA |  | SECONDARY | 9.50 | 15.0 | 52. | 20.0 | 6.2 | 20.1 | 1.94 |
| JAMES | PINNERS POINT S | 25003 | VA |  | PRIMARY | 9.69 | 16.4 | 137. | 66.4 | 9.5 | 20.8 | 2.33 |
| JAMES | RICHMOND STP | 25402 | VA |  | SECONDARY | 61.03 | 70.0 | 6. | 7.5 | 5.8 | 7.7 | 2.00 |
| JAMES | SMITHFIELD LAGO | 23809 | VA |  | PRIMARY | 0.24 | 0.5 | 64. | 64.0 | 9.5 | 20.8 | 2.00 |
| JAMES | SUFFOLK STP | 23205 | VA |  | SECONDARY | 1.40 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| JAMES | WASHINGTON PLAN | 21211 | VA |  | PRIMARY | 0.55 | 0.0 | 71. | 45.8 | 9.5 | 20.8 | 1.95 |
| JAMES | WESTERN BRANCH | 25232 | VA |  | PRIMARY | 1.92 | 0.0 | 97. | 55.3 | 9.5 | 20.8 | 2.00 |
| JAMES | WILLIAMSBURG W | 25267 | VA |  | SECONDARY | 8.90 | 19.4 | 12. | 20.9 | 8.0 | 18.5 | 1.90 |
| PATUXEN | BOWIE WWTP | 21628 | MD |  | SECONDARY | 2.50 | 3.3 | 20. | 16.3 | 8.8 | 33.0 | 2.27 |
| PATUXEN | FORT MEADE WWTP | 3280 | MD |  | SECONDARY | 3.20 | 3.2 | 30. | 30.0 | 8.0 | 18.5 | 6.50 |
| PATUXEN | MD CITY WWTP | 23132 | MD |  | SECONDARY | 0.70 | 2.6 | 10. | 17.8 | 9.6 | 21.8 | 1.34 |
| PATUXEN | MD CORRECTIONAL | 23957 | MD |  | SECONDARY | 0.85 | 0.7 | 65. | 115.0 | 8.5 | 8.6 | 0.42 |
| PATUXEN | PARKWAY STP | 21725 | MD |  | SECONDARY | 5.20 | 7.5 | 2. | 2.8 | 2.0 | 14.0 | 2.04 |
| PATUXEN | PATUXENT WWTP | 21652 | MD |  | SECONDARY | 3.60 | 9.6 | 9. | 9.4 | 5.5 | 21.0 | 2.56 |
| PATUXEN | SAVAGE WWTP | 21547 | MD |  | SECONDARY | 7.50 | 19.0 | 9. | 16.8 | 8.0 | 22.0 | 2.27 |
| PATUXEN | WESTERN BRANCH | 21741 | MD |  | SECONDARY | 13.90 | 23.7 | 6. | 5.1 | 3.5 | 16.0 | 1.53 |
| POTOMAC | ALEXANDRIA STP | 25160 | VA |  | PHOS REM | 26.96 | 54.0 | 23. | 16.6 | 0.9 | 15.0 | 2.03 |
| POTOMAC | AQUIA REGIONAL | 60968 | VA |  | PHOS REM | 0.90 | 3.0 | 11. | 17.4 | 1.5 | 15.0 | 2.00 |
| POTOMAC | ARLINGTON CO WP | 25143 | VA |  | PHOS REM | 22.27 | 30.0 | 12. | 13.5 | 3.1 | 18.5 | 1.95 |
| POTOMAC | BELMONT SEWAGE | 25062 | VA |  | PHOS REM | 1.40 | 0.0 | 21. | 12.0 | 1.5 | 15.0 | 2.00 |
| POTOMAC | BLUE PLAINS BYP | 0 | DC |  | PRIMARY | 27.60 | 0.0 | 30. | 115.0 | 4.6 | 20.3 | 2.00 |
| POTOMAC | BLUE PLAINS STP | 21199 | DC |  | PHOS REM | 317.00 | 309.0 | 10. | 15.0 | 1.2 | 12.2 | .00 |
| POTOMAC | CHAMBERSBURG WW | 26051 | PA | YES | PHOS REM | 2.65 | 5.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| POTOMAC | CHARLES TOWN ST | 22349 | WV |  | SECONDARY | 0.53 | 0.8 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| POTOMAC | CLAIBORNE RUN S | 28096 | VA |  | PHOS REM | 0.81 | 0.0 | 19. | 20.7 | 1.5 | 15.0 | 2.00 |
| POTOMAC | COLONIAL BEACH | 26409 | VA |  | SECONDARY | 0.72 | 0.8 | 15. | 19.0 | 8.0 | 18.5 | 2.00 |
| POTOMAC | CUMBERLAND WWTP | 21598 | MD |  | SECONDARY | 9.10 | 10.0 | 3. | 3.7 | 4.1 | 15.3 | 0.39 |
| POTOMAC | DALE SERVICE CO | 24724 | VA |  | PHOS REM | 2.30 | 4.0 | 6. | 5.5 | 1.5 | 15.0 | 2.00 |
| POTOMAC | DALE SERVICE CO | 24678 | VA |  | PHOS REM | 2.00 | 2.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| POTOMAC | DOGUE CREEK C.S | 25381 | VA |  | PHOS REM | 2.10 | 0.0 | 14. | 0.5 | 1.5 | 15.0 | 2.00 |
| POTOMAC | DUMFRIES SEWAGE | 25097 | VA |  | PHOS REM | 0.80 | 0.0 | 19. | 14.0 | 1.5 | 15.0 | 2.00 |
| POTOMAC | FEATHERSTONE SE | 25071 | VA |  | PHOS REM | 0.96 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |

(CONTINUED)

TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCR POLICY | TREAT. | FLOW (MGD) | | EFFLUENT CONCENTRATION (MG/L | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1980 | 2000 | BOD5 | TSS | TP | TN | TRC |
| POTOMAC | FISHERSVILLE ST | 25291 | VA | | PHOS REM | 0.60 | 2.1 | 7. | 5.8 | 1.5 | 15.0 | 2.0 |
| POTOMAC | FLATLICK CS | 26620 | VA | | PHOS REM | 0.36 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | FORT DETRICK | 0 | MD | | SECONDARY | 1.03 | 1.0 | 3. | 30.0 | 7.0 | 15.0 | 2.0 |
| POTOMAC | FREDERICK CITY | 21610 | MD | | SECONDARY | 4.40 | 7.0 | 76. | 26.6 | 9.3 | 25.6 | 3.8 |
| POTOMAC | FRONT ROYAL STP | 62812 | VA | | SECONDARY | 1.34 | 2.0 | 19. | 17.3 | 8.0 | 18.5 | 2.0 |
| POTOMAC | GETTYSBURG REGI | 21563 | PA | | SECONDARY | 1.39 | 1.5 | 30. | 30.0 | 8.0 | 18.5 | 2.0 |
| POTOMAC | GREENBRIAR C.S. | 26603 | VA | | PHOS REM | 0.69 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | HAGERSTOWN WPCF | 21776 | MD | | SECONDARY | 5.74 | 8.0 | 18. | 40.3 | 4.6 | 28.3 | 2.3 |
| POTOMAC | HALFWAY SUBDIST | 20214 | MD | | SECONDARY | 0.90 | 1.6 | 33. | 22.5 | 8.5 | 18.1 | 2.1 |
| POTOMAC | HARRISONBURG-RO | 60640 | VA | | PHOS REM | 4.90 | 8.0 | 5. | 7.4 | 1.5 | 15.0 | 2.0 |
| POTOMAC | INDIAN HEAD WWT | 20052 | MD | | SECONDARY | 0.28 | 0.5 | 15. | 15.0 | 6.0 | 15.0 | 2.0 |
| POTOMAC | KEYSER TRT SYS | 24392 | WV | | PRIMARY | 1.20 | 1.1 | 135. | 265.0 | 9.5 | 20.8 | 2.0 |
| POTOMAC | LA PLATA WWTP | 20524 | MD | | SECONDARY | 0.20 | 0.3 | 15. | 15.0 | 6.0 | 15.0 | 1.8 |
| POTOMAC | LEESBURG SAN SE | 21377 | VA | | PHOS REM | 0.90 | 2.5 | 10. | 6.1 | 1.5 | 15.0 | 2.0 |
| POTOMAC | LEONARDTOWN STP | 24767 | MD | | PRIMARY | 0.25 | 0.9 | 135. | 265.0 | 6.3 | 25.0 | 5.1 |
| POTOMAC | LIBERTA COLL SY | 26344 | VA | | PHOS REM | 0.32 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | LITTLE HUNTING | 25372 | VA | | PHOS REM | 4.20 | 0.0 | 11. | 11.5 | 1.5 | 15.0 | 2.0 |
| POTOMAC | LOWER POTOMAC S | 25364 | VA | | PHOS REM | 22.20 | 54.0 | 7. | 30.0 | 2.3 | 15.0 | 2.0 |
| POTOMAC | MANASSAS PARK N | 28053 | VA | | PHOS REM | 0.21 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | MARTINSBURG S.T | 23167 | WV | | SECONDARY | 2.26 | 5.0 | 30. | 30.0 | 8.0 | 18.5 | 2.0 |
| POTOMAC | MATTAWOMAN | 21865 | MD | | SECONDARY | 2.20 | 5.0 | 5. | 30.0 | 5.0 | 15.0 | 0.3 |
| POTOMAC | MELROSE SEWAGE | 26158 | VA | | PHOS REM | 0.20 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | MIDDLE CUB C.S. | 26638 | VA | | PHOS REM | 0.58 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | MOONEY STP (OCC | 25101 | VA | | PHOS REM | 6.20 | 12.0 | 3. | 3.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | NEABSCO SEWAGE | 25089 | VA | | PHOS REM | 1.25 | 0.0 | 20. | 24.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | OCCOQUAN SEWAGE | 26131 | VA | | SECONDARY | 0.43 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.0 |
| POTOMAC | PINE HILL RUN W | 21679 | MD | | SECONDARY | 2.20 | 4.5 | 30. | 30.0 | 5.7 | 18.2 | 2.1 |
| POTOMAC | PISCATAWAY WWTP | 21539 | MD | | PHOS REM | 15.00 | 30.0 | 7. | 6.5 | 0.7 | 22.4 | 1.3 |
| POTOMAC | SENECA CREEK IN | 21491 | MD | | PHOS REM | 4.70 | 0.0 | 1. | 5.6 | 0.5 | 17.2 | 0.7 |
| POTOMAC | STAUNTON STP | 25224 | VA | | PHOS REM | 1.55 | 4.5 | 19. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | STRASBURG STP | 20311 | VA | | PRIMARY | 0.51 | 0.7 | 296. | 150.5 | 9.5 | 20.8 | 2.0 |
| POTOMAC | UPPER CUB W P C | 26646 | VA | | PHOS REM | 0.19 | 0.0 | 15. | 15.0 | 1.5 | 15.0 | 2.0 |
| POTOMAC | UPPER OCCOQUAN | 24988 | VA | | SECONDARY | 7.25 | 10.9 | 0. | 0.2 | 0.0 | 18.1 | 1.2 |
| POTOMAC | UPRC WWTP | 21687 | MD | | SECONDARY | 22.40 | 21.6 | 65. | 30.0 | 0.9 | 2.6 | 2.0 |
| POTOMAC | WARRENTON STP | 21172 | VA | | PHOS REM | 0.60 | 1.5 | 16. | 18.3 | 1.5 | 15.0 | 2.0 |
| POTOMAC | WAYNESBORO STP | 20621 | PA | | SECONDARY | 0.81 | 1.6 | 30. | 30.0 | 8.0 | 18.5 | 2.0 |
| POTOMAC | WAYNESBORO STP | 25151 | VA | | PRIMARY | 2.39 | 4.3 | 23. | 30.3 | 8.5 | 18.5 | 2.0 |
| POTOMAC | WESTGATE PUMPOV | 25399 | VA | | SECONDARY | 8.39 | 0.0 | 8. | 9.7 | 4.6 | 18.5 | 2.0 |
| POTOMAC | WESTMINSTER WWT | 21831 | MD | | SECONDARY | 1.90 | 3.0 | 4. | 6.8 | 6.0 | 22.0 | 2.2 |
| POTOMAC | WINCHESTER S T | 25135 | VA | | PHOS REM | 2.79 | 0.0 | 52. | 10.4 | 1.5 | 15.0 | 2.0 |

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TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCB POLICY | TREAT. | FLOW (MGD) 1980 | FLOW (MGD) 2000 | EFFLUENT CONCENTRATION (MG/L) BOD5 | TSS | TP | TN | TRC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RAPP | CULPEPER S T P | 21059 | VA | | SECONDARY | 1.38 | 3.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| RAPP | FREDERICKSBURG | 25127 | VA | | SECONDARY | 2.00 | 0.0 | 24. | 25.8 | 8.0 | 18.5 | 2.00 |
| RAPP | KILMARNOCK STP | 20788 | VA | | SECONDARY | 0.20 | 0.2 | 20. | 18.5 | 8.0 | 18.5 | 2.00 |
| RAPP | MASSAPONAX REGI | 25658 | VA | | SECONDARY | 1.30 | 3.0 | 11. | 27.0 | 8.0 | 18.5 | 2.00 |
| RAPP | REEDVILLE STP | 60712 | VA | | SECONDARY | 0.20 | 0.2 | 26. | 27.9 | 8.0 | 18.5 | 2.00 |
| RAPP | TAPPAHANNOCK ST | 20265 | VA | | PRIMARY | 0.19 | 0.4 | 45. | 37.0 | 8.5 | 18.5 | 2.00 |
| SUSQUHAN | ALTOONA EASTERL | 27014 | PA | | PHOS REM | 6.20 | 5.2 | 13. | 9.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | ALTOONA WESTERL | 27022 | PA | | PHOS REM | 6.26 | 6.7 | 15. | 7.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | ANNVILLE STP | 21806 | PA | YES | PHOS REM | 0.87 | 0.9 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | ATHEN-SAYRE WWT | 43681 | PA | | PRIMARY | 1.09 | 2.1 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | BATH WWTP | 21431 | NY | | SECONDARY | 0.62 | 1.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | BEDFORD BORO S. | 22209 | PA | | PHOS REM | 0.61 | 0.8 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | BELLEFONTE MUN | 20486 | PA | | PHOS REM | 1.22 | 2.1 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | BERWICK STP | 23248 | PA | | PRIMARY | 3.00 | 4.0 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | BING JOHN CITY | 24414 | NY | | SECONDARY | 19.99 | 18.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | BLOOMSBURG S.T. | 27171 | PA | | SECONDARY | 2.15 | 4.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | CARLISLE BOROUG | 26077 | PA | YES | SECONDARY | 2.87 | 6.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | CHEMUNG CO SD # | 36986 | NY | | SECONDARY | 5.50 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | CHEMUNG COUNTY | 35742 | NY | | PRIMARY | 7.20 | 26.0 | 65. | 115.0 | 8.5 | 18.5 | 2.00 |
| SUSQUHAN | CLARKS SUMMIT S | 28576 | PA | | PHOS REM | 0.80 | 1.3 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | CLEARFIELD SEW | 26310 | PA | | SECONDARY | 1.48 | 3.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | COLUMBIA SEWAGE | 26123 | PA | YES | PHOS REM | 1.29 | 2.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | CORNING WWTP | 25721 | NY | | PHOS REM | 1.78 | 2.1 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | CORTLAND STP | 27561 | NY | | PHOS REM | 5.98 | 10.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | CURWENSVILLE ST | 24759 | PA | | PRIMARY | 0.60 | 0.5 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | DALLAS AREA MUN | 26221 | PA | | PHOS REM | 1.65 | 2.4 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | DANVILLE STP | 23531 | PA | | SECONDARY | 2.04 | 3.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | DERRY TOWNSHIP | 26484 | PA | YES | PHOS REM | 1.71 | 5.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | DOVER TOWNSHIP | 20826 | PA | YES | PHOS REM | 1.92 | 3.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | EAST PENNSBORO | 38415 | PA | YES | PHOS REM | 1.74 | 3.7 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | ELIZABETHTOWN S | 23108 | PA | YES | PHOS REM | 1.15 | 3.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | ENDICOTT STP | 27669 | NY | | SECONDARY | 6.40 | 8.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | EPHRATA STP | 27405 | PA | YES | SECONDARY | 2.41 | 3.9 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | HAMILTON WPC PL | 20672 | NY | | SECONDARY | 0.94 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | HAMPDEN TWP WWT | 28746 | PA | YES | PHOS REM | 1.00 | 1.5 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | HANOVER-MCSHERR | 26875 | PA | YES | SECONDARY | 2.68 | 3.6 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | HARRISBURG S. T | 27197 | PA | YES | PHOS REM | 20.45 | 30.9 | 25. | 37.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | HAZELTON SEWAGE | 26921 | PA | | SECONDARY | 7.00 | 7.6 | 16. | 16.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | HIGHSPIRE BORO | 24040 | PA | YES | PHOS REM | 0.75 | 1.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |

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TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCB POLICY | TREAT. | FLOW (MGD) |  | EFFLUENT CONCENTRATION (MG/L) |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | 1980 | 2000 | BOD5 | TSS | TP | TN | TRC |
| SUSQUHAN | HOLLIDAYSBURG B | 23493 | PA |  | PHOS REM | 0.95 | 1.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | HOLLIDAYSBURG R | 23493 | PA |  | PHOS REM | 0.95 | 1.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | HORNELL WPCP | 23647 | NY |  | SECONDARY | 2.70 | 4.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | HUNTINGDON SEW | 26191 | PA |  | PRIMARY | 1.85 | 1.9 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | JERMYN-ARCHBALD | 27065 | PA |  | SECONDARY | 2.30 | 3.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | JERSEY SHORE ST | 28665 | PA |  | SECONDARY | 0.60 | 0.8 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | KELLY STP | 28681 | PA |  | PHOS REM | 1.30 | 2.4 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LANCASTER AREA | 42269 | PA | YES | PHOS REM | 2.85 | 12.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LANCASTER NORTH | 26719 | PA | YES | SECONDARY | 8.25 | 0.0 | 27. | 41.4 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | LANCASTER SOUTH | 26743 | PA | YES | SECONDARY | 8.50 | 29.6 | 19. | 20.7 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | LEBANON WWTP | 27316 | PA | YES | PHOS REM | 5.50 | 6.6 | 7. | 6.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LEMOYNE BORO MA | 26441 | PA | YES | PHOS REM | 1.80 | 2.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LEWISBURG STP | 21121 | PA |  | SECONDARY | 1.55 | 2.4 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | LEWISTOWN SEWAG | 26280 | PA |  | SECONDARY | 1.42 | 2.4 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | LITITZ SAN STP | 20320 | PA | YES | PHOS REM | 1.50 | 3.5 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LITTLESTOWN SAN | 21229 | PA |  | PRIMARY | 0.36 | 0.8 | 65. | 115.0 | 8.5 | 18.5 | 2.00 |
| SUSQUHAN | LOCK HAVEN CITY | 25933 | PA |  | PHOS REM | 3.30 | 3.7 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LOWER ALLEN TOW | 27189 | PA | YES | PHOS REM | 1.96 | 5.9 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | LOWER LACKAWANN | 26361 | PA |  | PHOS REM | 2.10 | 6.0 | 11. | 7.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | MANHEIM BOROUGH | 20893 | PA | YES | SECONDARY | 0.94 | 1.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MARYSVILLE TREA | 21571 | PA | YES | SECONDARY | 0.63 | 0.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MECHANICSBURG S | 20885 | PA | YES | SECONDARY | 1.03 | 2.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MIDDLETOWN WPCP | 20664 | PA | YES | PHOS REM | 0.96 | 2.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | MIFFLINBURG WWT | 28461 | PA |  | SECONDARY | 0.70 | 0.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MILLERSBURG BOR | 22535 | PA | YES | SECONDARY | 0.60 | 1.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MILLERSVILLE BO | 26620 | PA | YES | SECONDARY | 0.65 | 0.7 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MILTON MA. | 20273 | PA |  | SECONDARY | 1.00 | 1.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MOSHANNON VALLE | 37966 | PA |  | SECONDARY | 0.94 | 1.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | MOUNT JOY STP | 21067 | PA | YES | PHOS REM | 0.88 | 1.7 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | NEW CUMBERLAND | 26654 | PA | YES | PHOS REM | 1.10 | 1.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | NEW FREEDOM WTP | 43267 | PA | YES | PHOS REM | 0.69 | 1.3 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | NEW HOLLAND STP | 21890 | PA | YES | SECONDARY | 0.61 | 1.1 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | NORWICH STP | 21423 | NY |  | PRIMARY | 1.72 | 2.0 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | ONEONTA WWT PLA | 31151 | NY |  | SECONDARY | 3.00 | 4.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | OWEGO WPC PLANT | 25798 | NY |  | SECONDARY | 0.85 | 2.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | PENN STATE UNIV | 26999 | PA |  | PHOS REM | 3.05 | 3.8 | 15. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | PENN TOWNSHIP S | 37150 | PA | YES | PHOS REM | 1.33 | 4.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | RICHFIELD SPRIN | 31411 | NY |  | PHOS REM | 0.55 | 0.3 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | ROARING SPRINGS | 20249 | PA |  | SECONDARY | 0.51 | 0.5 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | SCRANTON SEWER | 26492 | PA |  | SECONDARY | 21.20 | 23.8 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | SELINSGROVE S.T | 24791 | PA |  | SECONDARY | 0.85 | 2.8 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | SHENANDOAH SEWA | 70386 | PA |  | PHOS REM | 0.80 | 2.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | SHIPPENSBURG ST | 30643 | PA | YES | PHOS REM | 1.21 | 2.7 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |

(CONTINUED)

TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCB POLICY | TREAT. | FLOW (MGD) 1980 | FLOW (MGD) 2000 | EFFLUENT CONCENTRATION (MG/L) BOD5 | TSS | TP | TN | TRC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUSQUHAN | SIDNEY WWTP | 29271 | NY | | SECONDARY | 0.83 | 1.7 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | SPRING CREEK PO | 26239 | PA | | PHOS REM | 2.85 | 3.0 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | SPRINGETTSBURY | 26808 | PA | YES | PHOS REM | 6.20 | 10.3 | 14. | 21.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | SUNBURY SEW TRE | 26557 | PA | | SECONDARY | 2.30 | 3.5 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | SWATARA TWP STP | 26735 | PA | YES | PHOS REM | 2.80 | 5.2 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | THROOP WWTP | 27090 | PA | | SECONDARY | 2.98 | 5.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | TOWANDA MUNICIP | 34576 | PA | | SECONDARY | 0.68 | 1.0 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | TYRONE BOROUGH | 26727 | PA | | PHOS REM | 4.90 | 5.1 | 16. | 28.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | WELLSBORO STP | 21687 | PA | | PRIMARY | 0.76 | 0.6 | 135. | 265.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | WEST END STP | 27049 | PA | | SECONDARY | 3.68 | 3.2 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | WESTERN CLINTON | 43893 | PA | | PHOS REM | 0.70 | 0.9 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| SUSQUHAN | WILLIAMSPORT CE | 27057 | PA | | SECONDARY | 6.09 | 7.4 | 15. | 11.2 | 8.0 | 18.5 | 2.00 |
| SUSQUHAN | WYOMING VALLEY | 26107 | PA | | PRIMARY | 40.00 | 40.0 | 116. | 61.0 | 9.5 | 20.8 | 2.00 |
| SUSQUHAN | YORK WATER POLL | 26263 | PA | YES | PHOS REM | 16.25 | 26.0 | 15. | 43.0 | 1.5 | 15.0 | 2.00 |
| W CHESAP | ABERDEEN WWTP | 21563 | MD | YES | PHOS REM | 1.50 | 4.0 | 10. | 33.0 | 4.6 | 10.2 | 2.15 |
| W CHESAP | ANNAPOLIS CITY | 21814 | MD | | SECONDARY | 4.70 | 10.0 | 8. | 8.6 | 4.5 | 20.8 | 1.50 |
| W CHESAP | BACK RIVER WWTP | 21555 | MD | YES | SECONDARY | 180.60 | 195.0 | 20. | 35.9 | 5.6 | 19.4 | 1.77 |
| W CHESAP | BROAD CREEK C.S | 23141 | MD | | SECONDARY | 0.22 | 0.0 | 30. | 30.0 | 8.0 | 18.5 | 1.65 |
| W CHESAP | BROADNECK WWTP | 21644 | MD | YES | SECONDARY | 2.10 | 4.0 | 8. | 9.2 | 4.5 | 15.6 | 2.69 |
| W CHESAP | BROADWATER WWTP | 24350 | MD | | SECONDARY | 0.40 | 1.0 | 3. | 15.0 | 2.0 | 14.8 | 1.17 |
| W CHESAP | CHESAPEAKE BEAC | 20281 | MD | | SECONDARY | 0.12 | 0.3 | 30. | 30.0 | 8.0 | 18.5 | 2.00 |
| W CHESAP | CONGOLEUM | 1384 | MD | | SECONDARY | 0.35 | 0.3 | 17. | 30.0 | 8.0 | 15.0 | 2.07 |
| W CHESAP | COX CRK WWTP | 21661 | MD | YES | SECONDARY | 6.40 | 19.2 | 79. | 86.5 | 7.9 | 27.4 | 1.91 |
| W CHESAP | CROWNSVILLE HOS | 23663 | MD | | SECONDARY | 0.15 | 0.3 | 30. | 30.0 | 8.0 | 18.5 | 1.16 |
| W CHESAP | EDGEWOOD ARSENA | 21229 | MD | YES | PHOS REM | 0.97 | 1.0 | 10. | 30.0 | 4.0 | 18.5 | 6.84 |
| W CHESAP | FREEDOM DISTRIC | 21512 | MD | | SECONDARY | 0.80 | 3.0 | 9. | 13.2 | 6.8 | 6.5 | 0.49 |
| W CHESAP | HAVRE DE GRACE | 20702 | MD | YES | PRIMARY | 1.10 | 1.9 | 155. | 38.0 | 9.5 | 28.5 | 7.00 |
| W CHESAP | JOPPATOWNE | 22535 | MD | | SECONDARY | 0.59 | 0.7 | 30. | 30.0 | 7.0 | 18.5 | 0.24 |
| W CHESAP | MD CORRECTION C | 27405 | MD | | SECONDARY | 0.47 | 0.4 | 47. | 30.0 | 15.0 | 32.0 | 1.55 |
| W CHESAP | PATAPSCO WW TRT | 21601 | MD | YES | PRIMARY | 30.00 | 76.0 | 157. | 113.8 | 6.5 | 16.5 | 5.22 |
| W CHESAP | PERRYVILLE WWTP | 20613 | MD | YES | SECONDARY | 0.73 | 1.6 | 30. | 30.0 | 8.0 | 18.5 | 5.75 |
| W CHESAP | PRINCE FREDERIC | 51381 | MD | | SECONDARY | 0.14 | 0.1 | 15. | 15.0 | 1.5 | 15.0 | 2.00 |
| W CHESAP | RISING SUN STP | 20265 | MD | | SECONDARY | 0.17 | 0.3 | 30. | 30.0 | 8.0 | 18.5 | 2.66 |
| W CHESAP | SOD RUN WWTP | 21709 | MD | YES | PHOS REM | 2.90 | 10.0 | 21. | 19.7 | 1.5 | 25.0 | 1.18 |
| W CHESAP | WOODLAND BEACH | 23051 | MD | | SECONDARY | 0.56 | 0.0 | 9. | 9.6 | 6.4 | 17.6 | 2.76 |
| W CHESAP | NORTHEAST | 22594 | MD | | SECONDARY | 0.0 | 2.0 | 30. | 30.0 | 7.5 | 16.0 | 2.00 |

(CONTINUED)

TABLE 22. (CONTINUED)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | UPCB POLICY | TREAT. | FLOW (MGD) |  | EFFLUENT CONCENTRATION (MG/ |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  | 1980 | 2000 | BOD5 | TSS | TP | TN | TR |
| YORK | ASHLAND STP | 24899 | VA |  | PRIMARY | 0.75 | 1.2 | 30. | 30.0 | 6.6 | 18.0 | 2. |
| YORK | DOSWELL STP | 29521 | VA |  | PHOS REM | 0.52 | 1.0 | 15. | 15.0 | 1.5 | 15.0 | 2. |
| YORK | YORK TREATMENT PLANT | ? | VA |  | SECONDARY | 0.00 | 15.0 | 30. | 30.0 | 8.0 | 18.5 | 2. |
| YORK | WEST POINT SEWE | 22195 | VA |  | PRIMARY | 0.41 | 0.6 | 28. | 28.8 | 8.5 | 18.5 | 2. |

## SECTION 8

# ALTERNATIVE NUTRIENT REMOVAL TECHNOLOGY (BIOLOGICAL)

Biological phosphorus removal provides an alternative to chemical treatment methods. It can be developed in activated sludge systems by cyclically subjecting the mixed liquor to anerobic (lack of nitrate, nitrite, or oxygen) and aerobic (presence of oxygen) conditions. Although factors affecting biological phosphorus removal are not completely understood (i.e., biological phosphorus removal mechanisms), effluent concentrations of 1 to 2 mg $L^{-1}$ phosphorus are obtainable. None of the three biological phosphorus proprietary processes described below are generically classified as Innovative/Alternative processes by the U.S. EPA. Due to significant engineering costs, biological phosphorus removal is not recommended for plants discharging less than 5.0 MGD.

## THE ANEROBIC/OXIC SYSTEM

The Anerobic/Oxic System relies on the concept of luxury phosphorus uptake by which certain sewage organisms are induced to store large amounts of polyphosphate. By wasting a portion of the organisms, phosphorus is removed from the wastewater. Any activated sludge process can be modified to incorporate the Anerobic/Oxic process. The process is relatively new, but operation of pilot plants in Allentown, Pennsylvania: Rochester, New York: and Largo, Florida have been very successful. Currently, a pilot plant is scheduled to go into operation in July 1982 at the Patapsco wastewater treatment plant. The Cox Creek POTW and several facilities administered by the Washington Suburban Sanitary Commission are also considering the Anerobic/Oxic process. In addition to phosphorus removal, the Anerobic/Oxic process can accomplish biological denitrification.

## PHOSTRIP

"Phostrip" is a combined biological-chemical precipitation process based on the use of activated sludge micro-organisms to transfer phosphorus from incoming wastewater to a small concentrated sub-stream for removal by chemical precipitation. The chemical-phosphorus reaction is pH dependent rather than stoichiometric. Therefore, the quantity of the chemical (lime) required is related more to the quantity of liquid treated than to the quantity of phosphorus contained in the liquid. Phostrip is a relatively new developement in municipal wastewater treatment. Large scale evaluations conducted at Seneca Falls, New York; and Reno/Sparks, Nevada have been favorable. Phostrip offers a dramatic saving in operating costs as a result of the reduced chemical requirement and sludge disposal costs.

## BARDENPHO

The Bardenpho Process is an activated sludge process designed to accomplish both biological nitrogen and phosphorus removal. Phosphorus is removed from the system in the waste sludge, yielding effluent phosphorus concentrations of 1 to 2 mg $L^{-1}$. The process was developed in South Africa in the early 1970's and is currently employed at plants in Palmetto, Florida and Kelowna, British Columbia, Canada.

## SECTION 9

# ESTIMATED COSTS AND PERCENT CHANGES IN NUTRIENT LOADS FOR DIFFERENT MANAGEMENT STRATEGIES

Tables 23 through 30 provide detailed information on nutrient reduction costs for management strategies applied to existing (1980) and future (2000) nutrient loads. Table numbers followed by the letter "a" address existing loads, and table numbers followed by "b" address future loads. For each strategy tested, the tables provide information on the estimated percent change in nutrient loads; the capital, O & M, and present-value costs; the present-value cost to remove one pound of nutrient; and the estimated monthly increases in household costs pursuant to implementation of the strategy.

TABLE 23a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE SUSQUEHANNA RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 58,200,000 | 2,900,000 |

| Strategy | Percent Change in Load | | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] | | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | | | | Nitrogen $/lb removed | Phosphorus $/lb removed | |
| P Ban | + 4 | - 4 | 0 | 10.15 | 105.4 | N increases | 29.47 | 0.62 |
| TP = 2 | +19 | -14 | 71.3 | 3.2*<br>11.3 | 33.2*<br>188.7 | N increases | 15.44 | 2 - 5 |
| TP = 1, TN = 6<br>TP = 1<br>TN = 6 | +12 | -17 | 71.3<br>226.1 | 12.5<br>53.2 | 201.4<br>779.1 | N increases | 14.07 | 2 - 5<br>6 - 10 |
| Level Two | -1 | -16 | 0 | .45 | 4.65 | 0.26 | 0.34 | 0 |
| TP=2 + Level Two | +18 | -29 | 71.3 | 11.75 | 191.8 | N increases | 7.66 | 2 - 3 |
| Mason-Dixon | ? | ? | | 15.7 | 109.0 | ? | ? | 0 |
| Level 2 + Level 3** | -5 | 22 | ? | ? | ? | ? | ? | 0 |

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*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

**Level 2 basin-wide and Level 3 in lower Susquehanna only. Calculated from deliver ratios.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

TABLE 23b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE SUSQUEHANNA RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
|  | 55,900,000 | 3,882,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/-4 | 0/+32 |  |  |  |  |  |  |
| Future TP=1, TN=6 |  |  |  |  |  |  |  |  |
| TP=1 |  | -13/-34 | 101.4 | 17.8 | 286.9 | N increases | 7.40 | 2 - 5 |
| TN=6 | +18/+22 |  | 340.7 | 82.2 | 1,194.8 |  |  | 6 - 10 |
| Future TP=2 + Level 2 | +22/+27 | -23/-41 | 101.4 | 16.6 | 273.3 | N increases | 5.77 | 2 - 5 |
| UCBP Policy | 0/+4 | 0/-24 | 19.8 | 3.46 | 55.7 | N increases | 2.07 | 2 - 5 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

TABLE 24a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE WEST CHESAPEAKE BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 15,984,000 | 2,391,000 |

| Strategy | Percent Change in Load | | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] | | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | | | | Nitrogen $/lb removed | Phosphorus $/lb removed | |
| P Ban | 0 | -19 | 0 | 5.1<br>1.9* | 53.0<br>19.7* | | 3.85 | 0.62 |
| TP = 2 | 0 | -43 | 58.3 | 9.1 | 132.9 | | 4.96 | 2 - 5 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -51 | 58.3 | 11.5 | 177.8 | | 4.90 | 2 - 5 |
| TN = 6 | -49 | | 124.4 | 38.5 | 524.4 | 2.23 | | 5 - 10 |
| Level Two | - 2 | -2.0 | 0 | 0.40 | 0.38 | 0.05 | 0.23 | 0 |
| TP=2 + Level Two | - 2 | -45 | 58.3 | 9.14 | 153.3 | 18.54 | 4.78 | 2 - 5 |
| UCBP Policy | 0 | -41 | 56.1 | 9.0 | 149.61 | | 5.04 | 2 - 5 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

TABLE 24b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE WEST CHESAPEAKE BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 19,767,000 | 3,524,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+23 | 0/+46 | | | | | | |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | -42/-60 | 80.8 | 16.7 | 254.11 | | 3.98 | 2 - 5 |
| TN=6 | -14/-30 | | 170.7 | 52.8 | 718.9 | 4.04 | | 6 - 10 |
| Future TP=2 + Level 2 | +22/-1 | -28/-51 | 80.8 | 16.0 | 247.4 | | 4.63 | 2 - 5 |
| UCBP Policy | +23/0 | -23/-47 | 74.8 | 15.6 | 237.0 | | 4.75 | 2 - 5 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

TABLE 25a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE EASTERN SHORE BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 8,741,000 | 833,000 |

| Strategy | Percent Change in Load | | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] | | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | | | | Nitrogen $/lb removed | Phosphorus $/lb removed | |
| P Ban | 0 | -9 | 0 | 1.13<br>0.17* | 11.8<br>1.8* | | 5.26 | 0.62 |
| TP = 2 | 0 | -14 | 6.4 | 0.88 | 15.61 | 0 | 5.85 | 3 - 5 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -15 | 6.4 | 1.1 | 17.9 | | 4.97 | 3 - 5 |
| TN = 6 | -7 | | 11.9 | 2.4 | 36.9 | 2.04 | | 7 - 10 |
| Level Two | -7 | -14 | 0 | 0.14 | 1.44 | 0.08 | 0.41 | 0 |
| TP=2 + Level Two | -7 | -25 | 6.4 | 1.02 | 17.0 | 0.98 | 2.73 | 3 - 5 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 25b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE EASTERN SHORE BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
|  | 9,281,000 | 1,016,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+6 | 0/+22 |  |  |  |  |  |  |
| Future TP=1, TN=6 |  |  |  |  |  |  |  |  |
| TP=1 |  | - 4/-21 | 11.3 | 1.94 | 31.4 |  | 4.93 | 3 - 5 |
| TN=6 | 0/-5 |  | 20.0 | 4.5 | 66.6 | 4.38 |  | 7 - 10 |
| Future TP=2 + Level 2 | 0/-6 | -13/-28 | 11.3 | 1.79 | 29.9 | 1.79 | 3.49 | 3 - 5 |
| Future Level 2 + P ban** | -1/-7 | -8/-24 | 0 | 1.47 | 15.3 | 0.82 | 2.07 | 0.62 |

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*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

**Extrapolated

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365\text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\text{ day}}\right)$ * 20 years]

TABLE 26a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE PATUXENT RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 2,493,000 | 478,000 |

| Strategy | Percent Change in Load | | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] | | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| | Nitrogen | Phosphorus | | | | Nitrogen $/lb removed | Phosphorus $/lb removed | |
| P Ban | 0 | -10 | 0 | 1.85<br>0.39* | 19.32<br>4.05* | | 14.08 | 0.92 |
| TP = 2 | 0 | -55 | 14.9 | 2.3 | 38.7 | | 4.94 | 2 - 4 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -64 | 14.9 | 2.6 | 41.9 | | 4.58 | 2 - 4 |
| TN = 6 | -30 | | 24.7 | 6.6 | 93.8 | 4.21 | | 6 - 8 |
| Level Two | - 1 | -1 | 0 | 0.007 | 0.07 | 0.14 | 0.46 | 0 |
| TP=2 + Level Two | - 1 | -55 | 14.9 | 2.3 | 38.8 | | 4.92 | 2 - 4 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 26b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE PATUXENT RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 3,332,000 | 851,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Exist/Future Phosphorus | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+34 | 0/+77 | | | | | | |
| Charette (1987) | -57/-68 | -63/-79 | 36.3 | 9.2 | 135.2 | 3.22 | 4.64 | 8 - 11 |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | -54/-74 | 25.4 | 4.6 | 73.2 | | 3.91 | 2 - 4 |
| TN=6 | -19/-40 | | 48.8 | 12.3 | 176.6 | 4.49 | | 6 - 7 |
| Future TP=2 + Level 2 | +36/+ 2 | -37/.65 | 25.4 | 4.01 | 67.0 | | 4.09 | 2 - 4 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 27a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE POTOMAC RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 35,077,000 | 2,866,000 |

| Strategy | Percent Change in Load: Nitrogen | Percent Change in Load: Phosphorus | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5]: Nitrogen $/lb removed | Present Value[5]: Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| P Ban | +1 | - 5 | 0 | 9.94<br>4.80* | 103.3<br>49.9* | | 24.24 | 0.62 |
| TP = 2 | +3 | -12 | 40.5 | 2.5 | 66.5 | N increases | 6.30 | 2 - 6 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -22 | 40.5 | 7.2 | 115.2 | | 6.02 | 2 - 6 |
| TN = 6 | -21 | | 312.2 | 92.4 | 1,272.4 | 5.81 | | 6 - 10 |
| Level Two | - 1 | -4 | 0 | 0.20 | 2.13 | 0.15 | 0.57 | 0 |
| TP=2 + Level Two | + 2 | -17 | 40.5 | 2.7 | 68.5 | N increases | 4.79 | 2 - 6 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

TABLE 27b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE POTOMAC RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 36,864,000 | 4,717,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+5 | 0/+65 | | | | | | |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | -14/-48 | 49.2 | 8.8 | 140.3 | | 2.08 | 2 - 4 |
| TN=6 | -18/-22 | | 330.0 | 92.6 | 1,581.0 | 6.49 | | 6 - 7 |
| Future TP=2 + Level 2 | +15/+9 | - 3/-41 | 49.2 | 7.8 | 130.2 | N increases | 2.26 | 2 - 4 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 28a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE RAPPAHANNOCK RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 2,945,000 | 278,000 |

| Strategy | Percent Change in Nitrogen Load | Percent Change in Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| P Ban | 0 | -4 | 0 | 0.40<br>0.07* | 4.2<br>0.7* | | 13.94 | 0.62 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -17 | 2.97 | 0.5 | 8.3 | | 5.83 | 4 - 5 |
| TN = 6 | -6 | | 5.82 | 1.0 | 16.3 | 3.28 | | 8 - 9 |
| Level Two | -2 | -5 | 0 | 0.033 | 0.35 | 0.21 | 0.82 | 0 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 28b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE RAPPAHANNOCK RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 2,809,000 | 282,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/-5 | 0/+1 | | | | | | |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | -13/-14 | 4.26 | 0.72 | 11.7 | | 10.26 | |
| TN=6 | - 5/0 | | 7.7 | 1.6 | 24.3 | 5.51 | | |
| Future TP=2 + Level 2 | + 4/+9 | -12/-13 | 4.26 | 0.67 | 11.2 | N | 10.03 | |
| Future Level 2** | - 2/-3 | - 4/-5 | | | 0.35 | | 0.82 | |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

**Extrapolated

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 29a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE YORK RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
|  | 2,329,000 | 221,000 |

| Strategy | Percent Change in Load: Nitrogen | Percent Change in Load: Phosphorus | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| P Ban | 0 | -6 | 0 | 0.5 | 5.2 |  | 14.11 | 0.62 |
| TP = 1, TN = 6 |  |  |  | 0* | 0* |  |  |  |
| TP = 1 |  | 0 | 0 |  |  |  |  |  |
| TN = 6 | 0 |  | 0 |  |  |  |  |  |
| Level Two | -3 | -8 | 0 | 0.049 | 0.51 | 0.2 | 0.40 | 0 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365\text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\text{ day}}\right)$ * 20 years]

TABLE 29b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE YORK RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 2,368,000 | 247,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Percent Change in Exist/Future Phosphorus Load | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+26 | 0/+122 | | | | | | |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | +18/-47 | 5.95 | 1.11 | 17.5 | | 2.57 | |
| TN=6 | + 8/-14 | | 11.3 | 3.15 | 44.0 | 3.66 | | |
| Future TP=2 + Level 2 | +24/-2 | +25/-44 | 5.95 | 0.97 | 16.0 | 10.73 | 2.51 | |
| Future Level 2 + P ban | | +77/-35 | 0 | 0.76 | 7.88 | | 2.65 | |

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*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

**Extrapolated

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling.

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[future load * percent change in future load * $\left(\frac{365\ \text{days}}{\text{year}} * \frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 30a. ESTIMATED COST AND PERCENT CHANGE IN EXISTING (1980) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE JAMES RIVER BASIN

| Existing load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 20,505,000 | 3,791,000 |

| Strategy | Percent Change in Load: Nitrogen | Percent Change in Load: Phosphorus | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| P Ban | 0 | -18 | 0 | 5.48<br>2.29* | 56.9<br>23.8* | | 2.82 | 0.62 |
| TP = 2 | +2 | -44 | 83.5 | 11.9 | 207.1 | | 4.13 | 2 - 5 |
| TP = 1, TN = 6 | | | | | | | | |
| TP = 1 | | -55 | 83.5 | 15.3 | 242.2 | | 3.88 | 2 - 5 |
| TN = 6 | -30 | | 153.7 | 41.9 | 589.7 | 3.22 | | 6 - 10 |
| Level Two | 0 | -1 | 0 | 0.09 | 1.0 | 1.13 | 1.06 | 0 |
| TP=2 + Level Two | 0 | -45 | 83.5 | 12.0 | 208.2 | | 4.09 | 2 - 5 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

[1] Based on 1980 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365\ \text{days}}{\text{year}}\right) * \left(\frac{\text{Mar-Oct}}{245\ \text{day}}\right)$ * 20 years]

TABLE 30b. ESTIMATED COST AND PERCENT CHANGE IN FUTURE (2000) NUTRIENT LOADINGS FOR MANAGMENT STRATEGIES IN THE JAMES RIVER BASIN

| Future load[1] (lbs) | Nitrogen (N) | Phosphorus (P) |
|---|---|---|
| | 25,102,000 | 5,007,000 |

| Strategy | Percent Change in Exist/Future Nitrogen Load | Exist/Future Phosphorus | Capital Cost[2] (millions $'s) | O & M[3] (annual) | Present Value[4] (capital + 20 yr) O & M | Present Value[5] Nitrogen $/lb removed | Present Value[5] Phosphorus $/lb removed | $/Household/Month |
|---|---|---|---|---|---|---|---|---|
| Existing | 0/+22 | 0/+32 | | | | | | |
| Future TP=1, TN=6 | | | | | | | | |
| TP=1 | | -49/-61 | 116.8 | 21.4 | 339.2 | | 3.68 | 2 - 5 |
| TN=6 | -24/-38 | | 216.5 | 60.8 | 847.7 | 2.97 | | 6 - 10 |
| Future TP=2 + Level 2 | +23/0 | -41/-56 | 116.8 | 16.7 | 290.3 | | 3.34 | 2 - 5 |
| Future Level 2 + P ban | 0/+22 | + 3/-21 | | | | | | 0.62 |

*O & M savings realized by POTWs if required to meet a phosphorus effluent limit.

**Extrapolated

[1] Based on year 2000 point source loadings, land use, and average year rainfall conditions, March to October.

[2] Cost to upgrade existing secondary treatment plant to provide nutrient removal (phosphorus -- chemical addition) (nitrogen -- nitrification/denitrification). Source: CAPDET.

[3] Includes chemicals, power, materials, labor, ammoritization of capital cost with 55 percent Federal funding, and sludge disposal by landfilling. Annual P ban costs are those borne by consumers ($2.74/capita).

[4] Capital costs + 20 years of O & M calculated with discount rate at 7.25 percent.

[5] Present value/[existing load * percent change * $\left(\frac{365 \text{ days}}{\text{year}} * \frac{\text{Mar-Oct}}{245 \text{ day}}\right)$ * 20 years]

## SECTION 10

# DETAILED POINT AND NONPOINT SOURCE NUTRIENT LOADS

In addition to summarizing information presented in Tables 5 and 6 of main text, Tables 31 through 38 indicate what percent of the basin's total nutrient load comes from above or below the fall line and the percent attributable specifically to industrial and municipal point sources. Actual stream-flow volumes (inches) that were simulated by the Chesapeake Bay watershed model during different rainfall conditions are also presented.

TABLE 31. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE SUSQUEHANNA RIVER BASIN

A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line |  | Below the Fall Line |  | TOTAL |
|---|---|---|---|---|---|
|  | Pounds | % of Total | Pounds | % of Total |  |
| Dry | 2,070,000 | 100 | 0 | 0 | 2,070,000 |
| Average | 2,900,000 | 100 | 0 | 0 | 2,900,000 |
| Wet | 6,300,000 | 100 | 0 | 0 | 6,300,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line |  |  |  |  |  | Below the Fall Line |  |  |  |  |  | TOTAL |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | PS |  |  | NPS |  |  | PS |  |  | NPS |  |  | PS |  |  | NPS |  |  |
|  | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 17 | 7 | 24 | - | - | - |  |  | 0 |  |  | 0 | 17 | 7 | 24 | - | - | - |
| Average | 16 | 7 | 23 | 60 | 17 | 77 |  |  | 0 |  |  | 0 | 16 | 7 | 23 | 60 | 17 | 77 |
| Wet | 8 | 4 | 12 | 77 | 11 | 88 |  |  | 0 |  |  | 0 | 8 | 4 | 12 | 77 | 11 | 88 |

B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line |  | Below the Fall Line |  | TOTAL |
|---|---|---|---|---|---|
|  | Pounds | % of Total | Pounds | % of Total |  |
| Dry | 47,300,000 | 100 | 0 | 0 | 47,300,000 |
| Average | 58,200,000 | 100 | 0 | 0 | 58,200,000 |
| Wet | 105,000,000 | 100 | 0 | 0 | 105,000,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line |  |  |  |  |  | Below the Fall Line |  |  |  |  |  | TOTAL |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | PS |  |  | NPS |  |  | PS |  |  | NPS |  |  | PS |  |  | NPS |  |  |
|  | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 9 | 1 | 10 | - | - | 90 |  |  | 0 |  |  | 0 | 9 | 1 | 10 | - | - | 90 |
| Average | 9 | 1 | 10 | 85 | 5 | 90 |  |  | 0 |  |  | 0 | 9 | 1 | 10 | 85 | 5 | 90 |
| Wet | 5 | 1 | 5 | 91 | 4 | 95 |  |  | 0 |  |  | 0 | 5 | 1 | 5 | 91 | 4 | 95 |

LEGEND

PS - Point Sources
M - POTW or municipal wastewater
I - Industrial

NPS - Nonpoint sources
C - Cropland
O - Other

*Simulated stream-flow volumes (inches): March-October.
Susquehanna: Dry, 8.7; Average, 11.7; Wet, 17.7.

## TABLE 32. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE WEST CHESAPEAKE BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 0 | 0 | 2,173,000 | 100 | 2,173,000 |
| Average | 0 | 0 | 2,391,000 | 100 | 2,391,000 |
| Wet | 0 | 0 | 3,045,000 | 100 | 3,045,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | | | 0 | | | 0 | 91 | 2 | 93 | - | - | 7 | 91 | 2 | 93 | - | - | 7 |
| Average | | | 0 | | | 0 | 83 | 2 | 85 | 8 | 7 | 15 | 83 | 2 | 85 | 8 | 7 | 15 |
| Wet | | | 0 | | | 0 | 66 | 1 | 67 | 25 | 8 | 33 | 66 | 1 | 67 | 25 | 8 | 33 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 0 | 0 | 13,594,000 | 100 | 13,594,000 |
| Average | 0 | 0 | 15,984,000 | 100 | 15,984,000 |
| Wet | 0 | 0 | 22,084,000 | 100 | 22,084,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | | | 0 | | | 0 | 72 | 13 | 85 | - | - | 15 | 72 | 13 | 85 | - | - | 15 |
| Average | | | 0 | | | 0 | 61 | 11 | 72 | 20 | 8 | 28 | 61 | 11 | 72 | 20 | 8 | 28 |
| Wet | | | 0 | | | 0 | 44 | 8 | 52 | 40 | 8 | 48 | 44 | 8 | 52 | 40 | 8 | 28 |

LEGEND

PS - Point Sources
M - POTW or municipal wastewater
I - Industrial

NPS - Nonpoint sources
C - Cropland
O - Other

*Simulated stream-flow volumes (inches): March-October.
West Chesapeake: Dry, 2.6; Average, 6.9; Wet, 15.7.

## TABLE 33. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE EASTERN SHORE BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 0 | 0 | 760,000 | 100 | 760,000 |
| Average | 0 | 0 | 833,000 | 100 | 833,000 |
| Wet | 0 | 0 | 2,117,000 | 100 | 2,117,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | | | 0 | | | 0 | 34 | 10 | 44 | - | - | 56 | 34 | 10 | 44 | - | - | 56 |
| Average | | | 0 | | | 0 | 31 | 9 | 40 | 50 | 10 | 60 | 31 | 9 | 40 | 50 | 10 | 60 |
| Wet | | | 0 | | | 0 | 12 | 4 | 16 | 79 | 5 | 84 | 12 | 4 | 16 | 79 | 5 | 84 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 0 | 0 | 7,191,000 | 100 | 7,191,000 |
| Average | 0 | 0 | 8,741,000 | 100 | 8,741,000 |
| Wet | 0 | 0 | 20,901,000 | 100 | 20,901,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | | | 0 | | | 0 | 10 | 3 | 13 | - | - | 87 | 10 | 3 | 13 | - | - | 87 |
| Average | | | 0 | | | 0 | 8 | 2 | 10 | 83 | 7 | 90 | 8 | 2 | 10 | 83 | 7 | 90 |
| Wet | | | 0 | | | 0 | 3 | 1 | 4 | 92 | 4 | 96 | 3 | 1 | 4 | 92 | 4 | 96 |

LEGEND

PS - Point Sources
M - POTW or municipal wastewater
I - Industrial

NPS - Nonpoint sources
C - Cropland
O - Other

*Simulated stream-flow volumes (inches): March-October.
Eastern Shore: Dry, 5.3; Average, 8.2; Wet, 15.4.

## TABLE 34. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE PATUXENT RIVER BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 344,000 | 73 | 130,000 | 27 | 474,000 |
| Average | 328,000 | 69 | 150,000 | 31 | 478,000 |
| Wet | 383,000 | 57 | 286,000 | 43 | 669,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 88 | 4 | 92 | - | - | 8 | 74 | 5 | 79 | - | - | 21 | 83 | 5 | 88 | - | - | |
| Average | 86 | 4 | 90 | 7 | 3 | 10 | 65 | 4 | 69 | 19 | 12 | 31 | 79 | 4 | 83 | 10 | 7 | 17 |
| Wet | 73 | 3 | 76 | 19 | 5 | 24 | 34 | 2 | 36 | 51 | 13 | 64 | 56 | 2 | 58 | 33 | 9 | 42 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 1,268,000 | 57 | 965,000 | 43 | 2,233,000 |
| Average | 1,118,000 | 45 | 1,313,000 | 55 | 2,493,000 |
| Wet | 1,780,000 | 39 | 2,813,000 | 61 | 4,593,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 69 | 2 | 71 | - | - | 29 | 47 | 1 | 48 | - | - | 52 | 60 | 1 | 61 | - | - | 39 |
| Average | 63 | 2 | 65 | 29 | 6 | 35 | 34 | 1 | 35 | 55 | 10 | 65 | 48 | 1 | 49 | 43 | 8 | 51 |
| Wet | 40 | 1 | 41 | 53 | 6 | 59 | 15 | 1 | 16 | 75 | 9 | 84 | 25 | 1 | 26 | 66 | 8 | 74 |

LEGEND

PS - Point Sources
    M - POTW or municipal wastewater
    I - Industrial

NPS - Nonpoint sources
    C - Cropland
    O - Other

*Simulated stream-flow volumes (inches): March-October.
Patuxent: Dry, 3.9; Average, 6.1; Wet, 16.2.

## TABLE 35. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE POTOMAC RIVER BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 717,000 | 27 | 1,940,000 | 73 | 2,657,000 |
| Average | 854,000 | 30 | 2,012,000 | 70 | 2,866,000 |
| Wet | 2,370,000 | 46 | 2,779,000 | 54 | 5,149,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 21 | 6 | 27 | - | - | 73 | 81 | 1 | 82 | - | - | 18 | 62 | 5 | 67 | | | 33 |
| Average | 11 | 4 | 15 | 52 | 33 | 85 | 78 | 1 | 79 | 10 | 11 | 21 | 54 | 5 | 59 | 23 | 18 | 41 |
| Wet | 5 | 2 | 7 | 72 | 21 | 93 | 56 | 1 | 57 | 31 | 12 | 43 | 31 | 3 | 34 | 50 | 16 | 66 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 13,800,000 | 44 | 17,807,000 | 56 | 31,607,000 |
| Average | 16,600,000 | 47 | 18,447,000 | 53 | 35,077,000 |
| Wet | 39,100,000 | 61 | 25,067,000 | 39 | 64,167,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 7 | 3 | 10 | - | - | 90 | 76 | 1 | 77 | - | - | 23 | 46 | 2 | 48 | - | - | 52 |
| Average | 7 | 3 | 10 | 83 | 7 | 90 | 73 | 1 | 74 | 17 | 9 | 26 | 42 | 2 | 44 | 48 | 8 | 56 |
| Wet | 7 | 3 | 10 | 84 | 6 | 90 | 54 | 1 | 55 | 37 | 8 | 45 | 27 | 1 | 28 | 66 | 6 | 72 |

LEGEND

PS - Point Sources
    M - POTW or municipal wastewater
    I - Industrial

NPS - Nonpoint sources
    C - Cropland
    O - Other

*Simulated stream-flow volumes (inches): March-October.
Potomac: Dry, 5.1; Average, 6.3; Wet, 13.8.

## TABLE 36. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE RAPPAHANNOCK RIVER BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 107,000 | 47 | 119,000 | 53 | 226,000 |
| Average | 104,000 | 37 | 174,000 | 63 | 278,000 |
| Wet | 285,000 | 37 | 486,000 | 63 | 771,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | .73 | .27 | 1.0 | - | - | 99 | 54 | 35 | 89 | - | - | 11 | 30 | 17 | 47 | - | - | 53 |
| Average | .73 | .27 | 1.0 | 58 | 41 | 99 | 37 | 24 | 61 | 27 | 12 | 39 | 25 | 14 | 39 | 39 | 22 | 61 |
| Wet | .73 | .27 | 1.0 | 75 | 24 | 99 | 13 | 9 | 22 | 69 | 9 | 78 | 9 | 5 | 14 | 71 | 15 | 86 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 1,530,000 | 71 | 615,000 | 29 | 2,145,000 |
| Average | 1,600,000 | 55 | 1,345,000 | 45 | 2,945,000 |
| Wet | 3,710,000 | 45 | 4,505,000 | 55 | 8,215,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 10 | 0 | 10 | - | - | 90 | 35 | 2 | 37 | - | - | 63 | 12 | 5 | 17 | - | - | 83 |
| Average | 10 | 0 | 10 | 72 | 18 | 90 | 16 | 1 | 17 | 73 | 10 | 83 | 9 | 4 | 13 | 72 | 15 | 87 |
| Wet | 10 | 0 | 10 | 78 | 12 | 90 | 4 | 1 | 5 | 89 | 6 | 95 | 5 | 2 | 7 | 84 | 9 | 93 |

LEGEND

PS - Point Sources
M - POTW or municipal wastewater
I - Industrial

NPS - Nonpoint sources
C - Cropland
O - Other

*Simulated stream-flow volumes (inches); March-October.
Rappahannock: Dry, 5.1; Average, 5.0; Wet, 12.5.

## TABLE 37. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE YORK RIVER BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 66,500 | 44 | 85,000 | 56 | 151,000 |
| Average | 78,000 | 35 | 143,000 | 65 | 221,000 |
| Wet | 332,000 | 44 | 457,000 | 56 | 759,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 7 | 0 | 7 | - | - | 93 | 25 | 59 | 84 | | | 16 | 24 | 26 | 50 | | | 50 |
| Average | 7 | 0 | 7 | 74 | 19 | 93 | 15 | 35 | 50 | 40 | 10 | 50 | 17 | 18 | 35 | 59 | 6 | 65 |
| Wet | 2 | 0 | 2 | 86 | 12 | 98 | 5 | 11 | 16 | 68 | 8 | 84 | 5 | 5 | 10 | 76 | 14 | 90 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line Pounds | Above the Fall Line % of Total | Below the Fall Line Pounds | Below the Fall Line % of Total | TOTAL |
|---|---|---|---|---|---|
| Dry | 693,000 | 50 | 693,000 | 50 | 1,386,000 |
| Average | 816,000 | 35 | 1,513,000 | 65 | 2,329,000 |
| Wet | 2,720,000 | 35 | 4,963,000 | 65 | 7,683,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 10 | 0 | 10 | - | - | 90 | 8 | 26 | 34 | - | - | 66 | 10 | 12 | 22 | - | - | 78 |
| Average | 10 | 0 | 10 | 78 | 12 | 90 | 3 | 12 | 15 | 76 | 9 | 85 | 6 | 7 | 13 | 77 | 10 | 87 |
| Wet | 10 | 0 | 10 | 82 | 8 | 90 | 1 | 4 | 5 | 90 | 5 | 95 | 3 | 4 | 7 | 87 | 6 | 93 |

LEGEND

PS - Point Sources
  M - POTW or municipal wastewater
  I - Industrial

NPS - Nonpoint sources
  C - Cropland
  O - Other

*Simulated stream-flow volumes (inches): March-October.
York: Dry, 4.4; Average, 5.4; Wet, 13.2.

## TABLE 38. POINT AND NONPOINT SOURCE NUTRIENT LOADS FOR THE JAMES RIVER BASIN

### A. PHOSPHORUS

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall* | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 657,000 | 18 | 2,915,000 | 82 | 3,572,000 |
| Average | 768,000 | 20 | 3,023,000 | 80 | 3,791,000 |
| Wet | 1,517,000 | 31 | 3,453,000 | 69 | 4,970,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 39 | 6 | 45 | - | - | 55 | 81 | 15 | 96 | - | - | 4 | 72 | 14 | 86 | - | - | 14 |
| Average | 31 | 5 | 36 | 46 | 18 | 64 | 78 | 15 | 93 | 3 | 4 | 7 | 68 | 13 | 81 | 12 | 7 | 19 |
| Wet | 18 | 3 | 21 | 63 | 16 | 79 | 68 | 13 | 81 | 14 | 5 | 19 | 53 | 10 | 63 | 29 | 8 | 37 |

### B. NITROGEN

1. Pounds (March through October) and Percentage of Total Load from Above and Below the Fall Line.

| Rainfall | Above the Fall Line | | Below the Fall Line | | TOTAL |
|---|---|---|---|---|---|
| | Pounds | % of Total | Pounds | % of Total | |
| Dry | 3,872,000 | 22 | 13,799,000 | 78 | 17,671,000 |
| Average | 5,076,000 | 25 | 15,429,000 | 75 | 20,505,000 |
| Wet | 11,070,000 | 36 | 19,609,000 | 64 | 30,679,000 |

2. Percentage from Point and Nonpoint Sources.

| Rainfall | Above the Fall Line | | | | | | Below the Fall Line | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PS | | | NPS | | | PS | | | NPS | | | PS | | | NPS | | |
| | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O | M | I | M+I | C | O | C+O |
| Dry | 9 | 1 | 10 | - | - | 90 | 65 | 23 | 88 | - | - | 12 | 53 | 18 | 71 | - | - | 29 |
| Average | 9 | 1 | 9 | 73 | 18 | 91 | 58 | 21 | 79 | 15 | 6 | 21 | 46 | 16 | 62 | 29 | 9 | 38 |
| Wet | 8 | 1 | 8 | 78 | 14 | 92 | 46 | 16 | 62 | 32 | 6 | 38 | 32 | 11 | 43 | 49 | 8 | 57 |

LEGEND

PS - Point Sources
  M - POTW or municipal wastewater
  I - Industrial

NPS - Nonpoint sources
  C - Cropland
  O - Other

*Simulated stream-flow volumes (inches): March-October.
James: Dry, 5.6; Average, 7.4; Wet, 13.6.
Appatomox: Dry, 3.3; Average, 4.2; Wet, 10.3.

## SECTION 11

# EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW

Point source effluent strategies were applied only to those POTWs with flows greater than 1 MGD. To provide a better feel for the number of facilities and the volume of waste water subject or not subject to these strategies, Table 39 through Table 46 present flow information in terms of POTWs with flows greater than or less than 1 MGD. Future and design flows are also included. In addition, existing (1980) flow-weighted mean effluent of total nitrogen and total phosphorus concentrations and the average size of the facility within each basin are also presented in these tables.

TABLE 39. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE SUSQUEHANNA RIVER BASIN

| POTWs | ABOVE THE FALL LINE |  |  |  |  |  | BELOW THE FALL LINE |  |  |  |  |  | TOTAL |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | 1980 Operational |  | 1980 Design |  | 2000 Projected |  | 1980 Operational |  | 1980 Design |  | 2000 Projected |  | 1980 Operational |  | 1980 Design |  | 2000 Projected |  |
|  | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 60 | 32 | 47 | 26 | 44 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 32 | 47 | 26 | 44 | 22 |
| Flow 1 MGD | 58 | 284 | 71 | 399 | 74 | 445 | 0 | 0 | 0 | 0 | 0 | 0 | 58 | 284 | 71 | 399 | 74 | 445 |
| Total | 118 | 316 | 118 | 425 | 118 | 467 | 0 | 0 | 0 | 0 | 0 | 0 | 118 | 316 | 118 | 425 | 118 | 467 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 17.55
Effluent total phosphorus concentration (mg $L^{-1}$) = 25.83
Average Flow = 2.67

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 40. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE WEST CHESAPEAKE BASIN

| | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| POTWs | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 6 | 18 | 6 | 17 | 6 | 21 | 6 | 18 | 6 | 17 | 6 |
| Flow 1 MGD | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 228 | 10 | 321 | 9 | 321 | 7 | 228* | 10 | 321 | 9 | 321 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 234 | 28 | 327 | 28 | 327 | 28 | 234* | 28 | 327 | 28 | 327 |

*includes 100 MGD of treated effluent transfered to and discharged by Bethlehem Steel.

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 19.27
Effluent total phosphorus concentration (mg $L^{-1}$) = 25.72
Average Flow = 8.34

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 41. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE EASTERN SHORE BASIN

| | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POTWs | 1980 Operational # | flow | 1980 Design # | flow | 2000 Projected # | flow | 1980 Operational # | flow | 1980 Design # | flow | 2000 Projected # | flow | 1980 Operational # | flow | 1980 Design # | flow | 2000 Projected # | flow |
| Flow 1 MGD | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 9 | 43 | 11 | 43 | 13 | 44 | 9 | 43 | 11 | 43 | 13 |
| Flow 1 MGD | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 6 | 23 | 6 | 22 | 5 | 12 | 6 | 23 | 6 | 22 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 21 | 49 | 34 | 49 | 35 | 49 | 21 | 49 | 34 | 49 | 35 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 16.80
Effluent total phosphorus concentration (mg $L^{-1}$) = 6.16
Average Flow = 0.43

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 42. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE PATUXENT RIVER BASIN

| POTWs | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 4 | 2 | 4 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 | 4 | 2 | 2 | 1 |
| Flow 1 MGD | 5 | 22 | 5 | 34 | 7 | 46 | 1 | 14 | 1 | 30 | 1 | 24 | 6 | 36 | 6 | 64 | 8 | 70 |
| Total | 9 | 24 | 9 | 36 | 9 | 47 | 1 | 14 | 1 | 30 | 1 | 24 | 10 | 38 | 10 | 66 | 10 | 71 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 18.68
Effluent total phosphorus concentration (mg $L^{-1}$) = 5.34
Average Flow = 3.78

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 43. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE POTOMAC RIVER BASIN

| POTWs | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 40 | 11 | 37 | 13 | 34 | 12 | 26 | 8 | 23 | 9 | 24 | 9 | 66 | 19 | 60 | 22 | 58 | 21 |
| Flow 1 MGD | 16 | 69 | 18 | 96 | 21 | 100 | 17 | 471 | 20 | 891 | 19 | 567 | 33 | 540 | 38 | 987 | 40 | 667 |
| Total | 56 | 80 | 55 | 109 | 55 | 112 | 43 | 479 | 43 | 900 | 43 | 576 | 99 | 559 | 98 | 1009 | 98 | 688 |

1980 Flow-weighted Mean Values

| | |
|---|---|
| Effluent total nitrogen concentration (mg $L^{-1}$) | = 13.99 |
| Effluent total phosphorus concentration (mg $L^{-1}$) | = 1.95 |
| Average Flow | = 5.64 |

LEGEND

# - Number of POTWs

Flow - Millions of gallons per day (MGD)

TABLE 44. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE RAPPAHANNOCK RIVER BASIN

| POTWs | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 1 |
| Flow 1 MGD | 1 | 1 | 1 | 3 | 1 | 3 | 2 | 3 | 2 | 9 | 2 | 5 | 3 | 4 | 3 | 12 | 3 | 8 |
| Total | 1 | 1 | 1 | 3 | 1 | 3 | 7 | 4 | 7 | 10 | 7 | 6 | 8 | 5 | 8 | 13 | 8 | 9 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 17.57
Effluent total phosphorus concentration (mg $L^{-1}$) = 6.28
Average Flow = 0.67

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 45. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE YORK RIVER BASIN

| POTWs | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 4 | 3 | 3 | 2 | 3 | 3 | 7 | 1 | 7 | 1.5 | 6 | 1.3 | 10 | 3 | 10 | 3.5 | 9 | 4.1 |
| Flow 1 MGD | 0 | 0 | 1 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 16.2 | 1 | 1 | 1 | 3 | 3 | 18.6 |
| Total | 4 | 3 | 4 | 5 | 4 | 5 | 7 | 1 | 7 | 1.5 | 8 | 17.5 | 11 | 4 | 11 | 6.5 | 12 | 22.7 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 17.83
Effluent total phosphorus concentration (mg $L^{-1}$) = 6.97
Average Flow = 0.35

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

TABLE 46. EXISTING, DESIGN, AND PROJECTED MUNICIPAL WASTEWATER FLOW FOR THE JAMES RIVER BASIN

| POTWs | ABOVE THE FALL LINE | | | | | | BELOW THE FALL LINE | | | | | | TOTAL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | | 1980 Operational | | 1980 Design | | 2000 Projected | |
| | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow | # | flow |
| Flow 1 MGD | 4 | 2 | 3 | 2 | 2 | 1 | 8 | 1 | 9 | 2 | 8 | 2 | 12 | 3 | 12 | 4 | 10 | 3 |
| Flow 1 MGD | 5 | 20 | 6 | 47 | 7 | 42 | 14 | 219 | 13 | 279 | 14 | 308 | 19 | 239 | 19 | 326 | 21 | 350 |
| Total | 9 | 22 | 9 | 49 | 9 | 43 | 22 | 220 | 22 | 281 | 22 | 310 | 31 | 242 | 31 | 330 | 31 | 353 |

1980 Flow-weighted Mean Values

Effluent total nitrogen concentration (mg $L^{-1}$) = 19.84
Effluent total phosphorus concentration (mg $L^{-1}$) = 5.48
Average Flow = 7.82

LEGEND
# - Number of POTWs
Flow - Millions of gallons per day (MGD)

SECTION 12

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# APPENDIX C

# AGRICULTURAL ACTIVITIES REPORT

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## FIGURES

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# AGRICULTURAL ACTIVITIES REPORT

## PREFACE

The Chesapeake Bay drainage basin covers 64,000 square miles. Agricultural activities vary greatly over an area this large, making the description of land use and the assessment of conservation needs a complex task. The Chesapeake Bay Program reviewed available literature and found no consistent accounting of agricultural activities that was both detailed enough to apply to a particular river basin and broad enough to cover the Maryland/Pennsylvania/Virginia region of the watershed. The Chesapeake Bay Program enlisted the help of the U.S. Department of Agriculture's Soil Conservation Service to collect information from Soil Conservation Districts on the agricultural activities and conservation needs of farmland in the Chesapeake Bay watershed. The Program needed this information for a number of purposes.

The main purpose of this project was to learn how the types of crops grown, tillage and conservation practices used, and the amounts of fertilizer, herbicides, and pesticides applied, varied across each river basin. This information was needed to refine the agricultural-runoff component of the Chesapeake Bay Program's Bay-wide computerized watershed model that simulates nutrient loadings to the Bay from upland point and nonpoint sources.

The second purpose of this effort was to provide information on a) what the agricultural community perceives to be the soil conservation needs in each area of the Bay watershed, b) what types of conservation farming practices would address these needs and what would be the cost, c) what are the trends in land-use conversions, types of crops grown, tillage practices, etc., and d) what the community believes are the major obstacles to achieving a greater degree of conservation. Answers to all these questions were needed to develop balanced management strategies designed to reduce point and nonpoint pollution in problem areas of the Bay.

All of these data were collected by worksheets sent out by the Soil Conservation Service to each of its soil conservation district field offices -- 35 Pennsylvania districts and 24 Maryland districts -- that lie within the Chesapeake Bay watershed (unfortunately, Virginia districts could not be included in the survey). The "District Worksheet" (Attachment C) was designed by a group comprised of members representing the following agencies:

- Chesapeake Bay Program
- Soil Conservation Service (Maryland, Pennsylvania, and Virginia branches)
- U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service (Maryland branch)
- Maryland State Soil Conservation Committee
- University of Maryland Cooperative Extension Service

- Maryland Department of Agriculture
- The Kent and Howard County, Maryland Soil Conservation Districts

To assist the Chesapeake Bay Program in interpreting the worksheet returns and to write a report summarizing the findings, the Soil Conservation Service entered into an interagency agreement with the Chesapeake Bay Program. The tasks in the agreement included a) administering the survey, b) providing responses to the Chesapeake Bay Program to summarize by sub-watershed, and c) writing a report that:

- summarized the agricultural activities, trends, and conservation needs from the worksheets (Section 2)
- described technical soil-erosion control alternatives that are representative of available conservation practices in terms of reducing soil loss and agricultural pollutant loadings (Section 4), and
- assessed administrative policy alternatives designed to increase soil conservation on farmland (Section 5).

The following is a compilation of the separate reports submitted by the Maryland and Pennsylvania Soil Conservation Services (USDA 1982a, USDA 1982b).

## SUMMARY OF AGRICULTURAL ACTIVITIES IN MARYLAND AND PENNSYLVANIA

### OVERVIEW OF SOIL EROSION

Loss of soil can be attributed to natural as well as human factors. As the cost of production increases, farmers till as much of their land as possible. Some of this land is of marginal quality, posing erosion hazards. Poor land use, a lack of conservation practices, and soil limitations contribute to erosion. Poor farming practices and erosion continue due to lack of adequate financial assistance, economic incentives for practicing conservation, and a knowledge of the benefits of proper land management.

Average annual soil losses throughout the Chesapeake Bay Basin are in the range of 6 to 8 tons/acre/year for most crops. Notable exceptions to this are tobacco and truck crops where the losses can range from 20 to 25 tons/ac/yr. The tolerable soil losses in the basin range from 1 to 5 tons/ac/yr with the vast majority of the soils in the 3 to 4 tons/ac/yr range.

The title of the soil loss equation is a misnomer because in reality it is a soil movement equation. It is not an equation to predict the amount of soil that leaves a field or how much of that soil is delivered to a waterway, stream, river, or the Bay. It is a measure of the soil that is moved within a field and what effect that movement will have on the productive capacity of that field or part of the field. Tolerable soil loss is defined as the amount of soil that can be lost and still maintain the productive capacity of agricultural land for sustained use. The soil forming factors of climate, topography, organic matter, and parent material, all acting together through time, will develop soils at this rate and, therefore, productivity will be maintained.

The amount of sediment delivered to streams, rivers, and the Bay is different from soil loss. Although dependent on the soil loss yields from fields, sediment delivery yield is also dependent on watershed size, proximity to watercourses, topography, and soil particle size.

#### Maryland

Cropland and pasture land in the Maryland portion of the Chesapeake Bay basin were 24.0 percent (1,425,000 acres) and 6.4 percent (380,000 acres), respectively, based on the 1978 Census of Agriculture. Soil loss from cultivated cropland is occurring in Maryland at an average annual rate of 7 tons/ac/yr (SCS 1977). Erosion results in sediment damage to adjacent land and waterways and to Chesapeake Bay. As a result of this depletion of soil resources, the productivity of agricultural land is reduced. According to the estimates of the U.S. Department of Agriculture's (USDA) 1977 National Resources Inventory, erosion is a primary threat on approximately 1.1 million acres of Maryland crop and pasture land. The problem of wind erosion also effects 39,000 productive acres.

## Pennsylvania

There are approximately 13 million acres or 20,800 square miles of drainage area located within Pennsylvania in the Susquehanna River Basin portion of Chesapeake Bay. The land use is 61 percent woodland, 23 percent cropland, 5 percent pastureland, and 11 percent urban and other land.

Although cropland is about one-fourth of the total acreage, it accounts for over two-thirds of the soil loss. Soil movement by sheet and rill erosion from farmland and woodland is estimated at 31 million tons of soil annually within the Susquehanna River Basin of Pennsylvania. Of this total, 21 million tons of soil are eroded from cropland at an average loss of 7.4 tons/ac/yr; 5 million tons from pastureland and other lands at an average loss of 2.4 tons/ac/yr; and 5 million tons from woodland at an average loss of 0.6 tons/ac/yr.

The soil loss from cropland in the Susquehanna River Basin is 34 percent higher than the entire Pennsylvania state average of 5.5 tons/ac/yr for cropland. The reason for this increase within the Susquehanna River Basin is the concentrated acreage of intensely cultivated cropland in the sub-basin downstream from Harrisburg. The maximum allowable soil loss ("T") on typical Pennsylvania soils is 3 to 4 tons/ac/yr. The annual soil loss from pastureland and woodland are at or below the state averages of 2.6 and 1.0 tons per acre, respectively.

## OVERVIEW OF AGRICULTURAL TRENDS

Agriculture in the basin has changed from a labor-intensive to a capital-intensive activity. The change has resulted in an increase in the size of individual farms. Additional land was not available for expansion, so smaller farm operations were absorbed into other units. The result is a decrease in the number of farming units in the basin. The farm numbers have been steadily decreasing since reaching the peak early in this century. For example, the number of farms in Pennsylvania is less than one-half the total in 1954, according to the Pennsylvania Analytical Summary, USDA 1977. Although the rate of decline has slowed, projections to the year 2020 are that the number of farms will continue to decrease to about one-half the present number.

As the number of farms has decreased, the average size of farms has increased about two-fold. The trend toward larger size farms will continue in the future. The rate of increase in average farm size will not be as rapid, however, as in the past. The opportunities for off-farm jobs is significantly affecting the number of farms being used as only rural residences.

Basin-wide, fewer conservation practices are applied to leased land because operators cannot recover their investment with short-term leases. The amount of farmland leased will increase as the number of farms continue to decrease and farm units increase. This poses a major conservation threat, as less conservation is applied on leased land than owned land.

Like farm numbers, the total land area committed to farming has declined. This is largely due to the continual conversion of farmland to urban or non-farm uses. This decrease is primarily in the cropland acreage. In Pennsylvania, over 52,000 acres and, in Maryland, over 62,000 acres of cropland are irretrievably lost annually to non-agricultural uses such as residencial, commercial, industrial, and transportation.

Unfortunately, the land that is best suited for agriculture is also the land best suited for these other uses. Agriculture is often forced to less desirable, fragile land, which is less suited to cropping and, when farmed, requires more energy and causes greater threats to conservation. Thus, programs aimed at preserving prime agricultural land, in effect, reduce the potential for increased agricultural runoff pollution.

Over the past 10 years, intensified cropping systems, such as double cropping of corn, small grain, soybeans, and the use of cover crops, have become more common and are expected to increase as agricultural land is converted to non-farm purposes. Increases in the use of these systems will be for economic reasons. For example, the profit margin is greater when the double cropping system is used because there is the opportunity for a third crop in two years. An additional economic advantage of double-cropping is that risks are spread over a number of crops. Double-cropping systems using tomatoes, cabbage, and potatoes are increasing. Cover crops are another example of an intensified cropping system which is used for economic reasons. Cover crops take up fertilizers in the winter which are then recycled in the following season as the crops decay, resulting in more efficient fertilizer usage. This system also controls runoff of fertilizers and sediment.

Fortunately, conservation tillage is expected to gain widespread acceptance as the preferred tillage on about 60 percent of Pennsylvania cropland, and 80 percent of Maryland cropland by the year 2000. Conservation tillage is a practice where the crop is planted directly into the ground with either minimal or no disturbance to the soil surface with 2,000 pounds of residue left on the soil surface. These practices are called minimum till and no-till respectively. The present extent of conservation tillage at the sub-basin level is shown in Table 1. These estimates were developed from district worksheet responses of tillage practices associated with major cropping systems; they are considered accurate plus or minus 10 percent.

There are three reasons that explain why conservation tillage will not become any more widespread. This tillage system is not acceptable on low-lying wet soils because the litter on the soil surface in the spring retards the warming of the soil, slowing seed germination, which in turn, reduces yields. With drainage practices, however, conservation tillage is feasible in these areas. Lack of soil warmth for seed germination without conventional turning of the soil may also be a limiting factor in cooler northern areas. A second reason is that in mountainous areas, part-time farming and the need for farmers to own conventional equipment makes it less feasible for farmers to purchase additional equipment. Third, in the tobacco growing regions, the chemicals farmers need to practice conservation tillage have not yet been developed; therefore, conventional tillage is necessary for adequate weed control.

Conservation tillage is an excellent conservation practice, but it alone cannot reduce soil losses to the tolerable limits. This fact is obvious from the analysis of soil losses in the river basin summaries that

TABLE 1. ESTIMATES OF TILLAGE PRACTICES IN THE MARYLAND AND PENNSYLVANIA PORTION OF THE CHESAPEAKE BAY BASIN

| Sub-basin | % Conventional Tillage | % Conservation Tillage |
|---|---|---|
| Susquehanna | | |
| Mouth to Harrisburg | 20-30 | 70-80 |
| Harrisburg to Sunbury | 30 | 70 |
| Juniata River Basin | 50 | 50 |
| West Branch | 90 | 10 |
| Above Sunbury | 75 | 25 |
| Potomac (Maryland Only) | | |
| North Branch | 100 | 0 |
| Harpers Ferry to Little Falls | 50 | 50 |
| Below Little Falls | 25-40 | 60-75 |
| Patuxent | | |
| Above Fall-line | 25-35 | 65-75 |
| Below Fall-line | 30-40 | 60-70 |
| West Chesapeake | 65 | 35 |
| Chester, Sassafras, and Elk Rivers | 20-30 | 70-80 |
| Middle-Lower Eastern Shore | 30 | 70 |

follow. Farmers often believe it is the cure-all practice. This trend of relying too heavily on conservation tillage alone will continue unless a vigorous information campaign is launched. In addition to staff needed for the information campaign, technical staff will be needed to service farmer demands, and a source of funding will be needed to apply the additional needed conservation practices.

Conservation practices such as strip-cropping, diversions, and waterways will be applied to the land at approximately the same rate each year as they are now in Maryland, but are expected to increase in Pennsylvania as more land is devoted to growing intensive row crops. The installation of animal waste systems is anticipated to increase.

Tobacco production is presently in an uncertain state as problems of mechanization, marketing, and price fluctuations affect the growth of the industry. Tobacco has traditionally been a high cost labor intensive crop to grow. In 1981, a number of machines were introduced that would mechanize harvesting the crop. Although these machines are presently in their infancy, the changes are here.

The future of the tobacco industry in southern Maryland is difficult to predict. Changes are happening rapidly after a long history of stability. In the past, Maryland tobacco was one of the few tobacco crops in the United States that was not under acreage allotments. Within the past few years, farmers in North Carolina have started to grow Maryland-Type 32 tobacco to the extent that in 1981 they grew one-third as much as Maryland. Because their crop matures earlier, it is marketed earlier. However, in 1982, the Federal government required that Maryland-Type 32 tobacco acreage be counted against the allotments. It is difficult to predict the effect this will have on the price Maryland farmers receive. Price influences profits which influence the acreage planted.

The only stabilizing factor in the tobacco industry within Pennsylvania is that, traditionally, the Amish community has concentrated on growing tobacco using family farm labor. Even so, tobacco cropland is anticipated to decrease in the Pennsylvania sub-basin below Harrisburg.

In Maryland, it is expected that there will be a slight reduction in the number of livestock; in Pennsylvania, however, the total number of livestock is anticipated to remain constant or show slight increases. Although the number of animals might not be reduced significantly, the distribution will be changed. They will be concentrated on fewer farms and concentrated in feedlots. The reduction in livestock on the eastern shore of Maryland has already been significant. In Pennsylvania, swine, chicken, and turkey production is expected to increase in the future. Sheep production is decreasing while horse and cattle populations remain constant.

The use of irrigation will increase. This is especially true for the eastern shore of Maryland where there is an ample supply of water and the land is flat. The great majority of the new systems will be center pivots. Along with the expansion in the numbers of new systems, farmers will increase the use of fertigation. Fertigation is a technique to apply liquid fertilizers through the irrigation system. By utilizing fertigation the farmers can increase yields by timing the application of fertilizer more closely to the needs of the crops.

The use of fertilizers and herbicides has, and will continue to, increase throughout all parts of the basin. Figure 1 includes state-wide fertilizer consumption trends for Maryland, Pennsylvania, and Virginia. The use of nitrogen appears to have substantially increased in the past 30 years, while that of phosphate has remained relatively constant.

Fertilizer is applied to farmland according to the needs of the crop and the farmer's goal as to crop yield. The rate of application is best determined by annual soil testing. In the absence of a soil test, farmers follow Extension Service recommendations for a given crop. Table 2 summarizes recommended rates for Maryland, which are very similar to Pennsylvania rates. In general, farmers do not apply more than the recommended rates as fertilizer is one of the most expensive production imputs. Relatively higher application rates are used on farms managed for high yields; for example, an additional 30 lbs of N and $K_2O$ and 15 lbs of $P_2O_5$ is recommended to achieve an additional 25 bushels of corn (1982

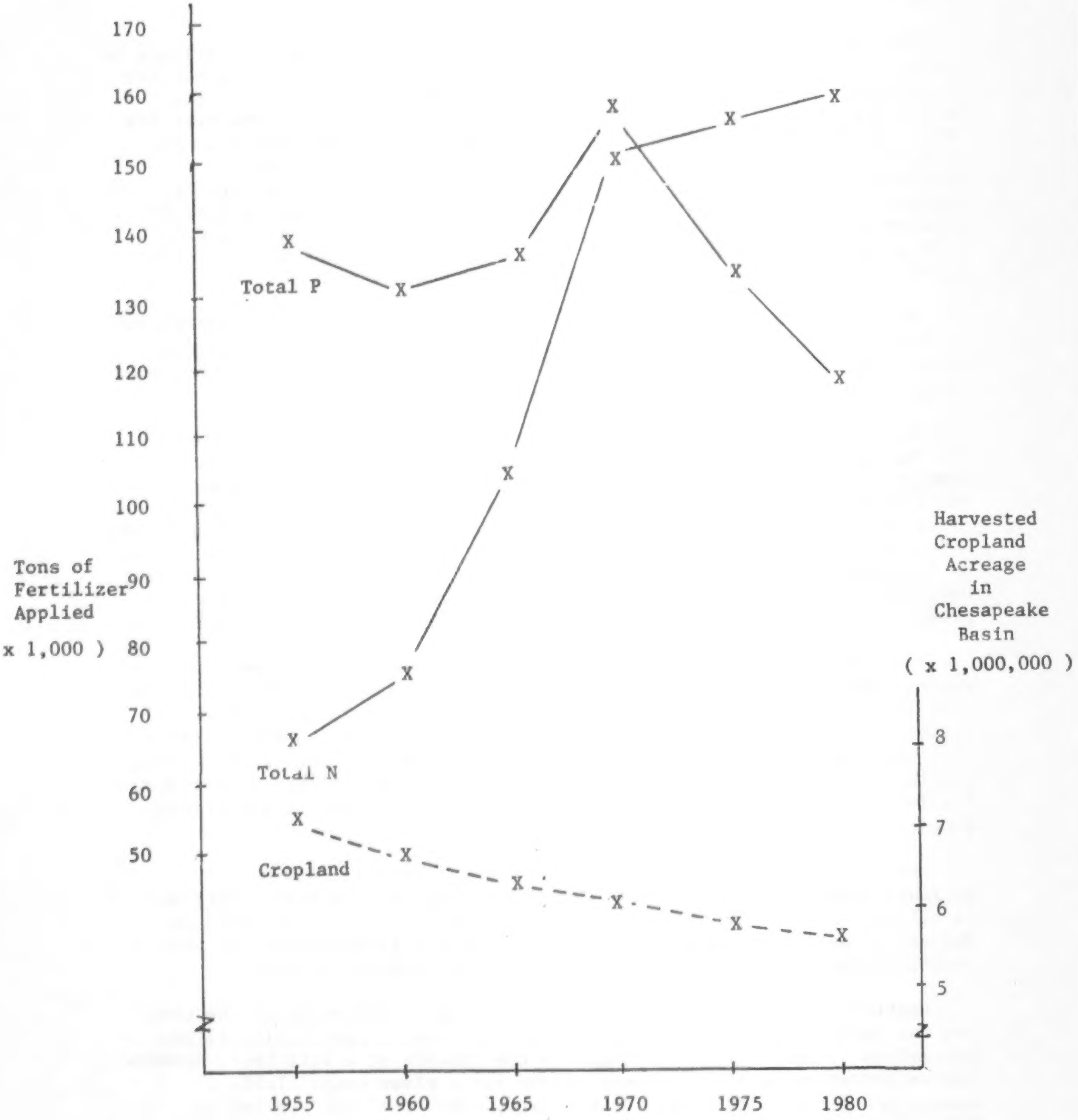

Figure 1. Comparison of TN and TP applied to toal harvested cropland in the Chesapeake Bay drainage areas of Virginia, Pennsylvania, and Maryland from 1950 to 1980, and total harvested cropland in the Chesapeake Bay basin from 1955 to 1980

TABLE 2. RANGES OF RECOMMENDED RATES OF FERTILIZER APPLICATION FOR VARIOUS CROPS IN MARYLAND. VALUES FOR PENNSYLVANIA ARE VERY SIMILAR (BASED ON 1980 FERTILIZER APPLICATION RATES, UNIVERSITY OF MARYLAND, COOPERATIVE EXTENSION SERVICE

| Crop | Pounds Per Acre Recommend Rates | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ |
| COMMERCIAL FERTILIZER | | | |
| Corn for Grain | 85 - 120 | 80 | 80 |
| Corn for Silage | 85 - 120 | 90 - 120 | 120 - 165 |
| (No-till Corn - add 40 lbs of N to above rates, broadcast application) | | | |
| Small Grains | 0 - 60 | 0 - 60 | 0 - 60 |
| Soybeans | 0 - 60 | 40 - 60 | 40 - 60 |
| Hay, Pasture, Silage | | | |
| New seedings | 0 - 40 | 60 - 170 | 60 - 260 |
| Maintenance | 0 - 50 | 40 - 70 | 50 - 210 |
| Rye for Grazing | 100 | 50 | 50 |
| MANURE | | | |
| [If manure is applied, for each ton applied, deduct the following amounts (lbs) of N, $P_2O_5$, and $K_2O$.] | | | |
| Cattle Manure | 5 - 10 | 3 | 3 |
| Poultry Manure | 25 - 50 | 20 | 10 |

(Note: lower N-values are for fall- and winter-applied manure. The higher N-values are for spring-applied, properly protected, and stored manure.)

Agronomy Guide, Pennsylvania State University, College of Agriculture Extension Service).

Manure is often used in addition to commercial fertilizer; ideally, commercial fertilizer should be reduced relative to the amount of manure applied, as shown in Table 2. Frequently, however, in regions with many livestock operations, animal waste management is inadequate, and excessive application rates are evident.

Herbicide usage will also increase in proportion to the increase in conservation tillage. Pesticides (which include herbicides) are applied throughout the basin in accordance with cooperative Extension Service recommendations and in accordance with label directions. All farmers applying pesticides have attended training sessions certifying them to apply pesticides. Table 3 includes the most commonly applied pesticides and recommended application rates. (Appendix B of this document contains information on the relationship between pesticides and Bay water.)

## OVERVIEW OF AGRICULTURAL PROGRAMS

Agricultural programs in the Chesapeake Bay basin occur at the Federal, state, and local levels. A detailed account of water quality management activities, with respect to agriculture, are present in the main text of this document; however, a number of special programs should be noted.

The USDA/EPA Rural Clean Water Program (RCWP) includes three projects in the Chesapeake Bay basin. One of the primary objectives of RCWP is to test the effectiveness of selected best management practices (BMPs) in reducing agricultural pollutant loadings. In Pennsylvania, the Conestoga Headwaters Rural Clean Water Project located in south-eastern Pennsylvania, (primarily in Lancaster County with portions in Lebanon, Berks, and Chester Counties) was selected in 1981 as a water quality project under the RCWP. The program provides approximately 2 million dollars in accelerated financial and technical assistance to owners and operators to install and maintain BMPs, to control agricultural nonpoint pollution for improved water quality. The Double Pipe Creek watershed in Carroll County, Maryland is a 3.6 million dollars RCWP project to improve water quality in this area -- the top-ranked, state-wide, potential critical area. The Nansemond-Chuckatuck watershed, which drains to the lower James River in Virginia, has also been targeted for approximately 2 million dollars by the RCWP.

While these three RCWP projects are directed to improve local water quality problems, their relative impact on Chesapeake Bay water quality is probably fairly low. Larger watersheds need to be assessed to reduce nutrients and sediment entering tidal waters. The proposed SCS Mason-Dixon Erosion Control project would target conservation assistance to the 22-county Piedmont region of south eastern Pennsylvania and central Maryland. The proposed 1984 SCS budget includes 300,000 dollars for the Maryland SCS office and 400,000 dollars for the Pennsylvania SCS office for technical assistance in this area.

In addition, each state has an approved Section 208 agricultural plan. Potential critical watersheds for sediment, animal waste, or nutrients have been identified (Appendix E, this document). Generally, plans call for targetting technical assistance and cost-sharing funds to these regions;

TABLE 3. COMMONLY APPLIED AGRICULTURAL CHEMICALS (SOURCES: 1981 PEST CONTROL RECOMMENDATIONS FOR FIELD CROP, UNIVERSITY OF MARYLAND COOPERATIVE EXTENSION SERVICE)

| Crop | Chemical | Application Rate) (per acre) |
|---|---|---|
| Corn (conventional) | Atrazine | 1-2 lb. |
| | Simazine | 1-2 lb. |
| | Roundup | 1.5-4 lb. |
| | Furidan | 12 lb. |
| Corn (no-till) | Same as above, but with Paraquat | 1 qt. |
| Soybeans (conventional) | Lasso | 2-4 qt. |
| | Lorox | 0.6-2 lb. |
| | Fluralin | 1-2 pt. |
| | Sevin | 0.6-1.3 lb. |
| Soybeans (no-till) | Lorox | 1-2 lb. |
| | Paraquat | 1 qt. |
| | Sevin | 0.6-1.3 lb. |
| Tobacco | Disyston | 27 lb. |
| | Diazinon | .75 pt. |
| | Sevin | 2 lb. |
| Small-grain | Banvel | .25-1.5 pts. |
| | Dylox | 1 lb. |
| | Cygon 400 | 43-54 lb. |

however, implementation of the plans has been hampered by a lack of adqeuate funding for implementation. For example, in Maryland, the SCS estimates that 24 million dollars is needed to address water quality problems in the top three critical watersheds only. Maryland soil conservation districts estimate that 20 soil conservationists and 35 technicians (at a cost exceeding 1 million dollars per year) would be required to assist 40 percent of the operating units in all critical areas with the development of a conservation plan.

At the local level, soil conservation districts provide technical assistance and administer BMP cost-sharing funds. In general, funding shortages prevent districts from achieving conservation goals. For example, Maryland's 24 soil conservation districts assisted agricultural landowners with soil conservation on 23,200 acres of crop and pasture land in 1980. At this rate, it would take 197 years to protect the 1.1 million acres of farmland needing treatment. The State of Maryland appropriated 10 million dollars in 1982 for cost-sharing of conservation practices; this funding will help in the areas needing immediate treatment, but much work will still remain to be done.

## SECTION 2
## AGRICULTURAL ACTIVITIES AND TRENDS, BY RIVER BASIN

### SUSQUEHANNA – PENNSYLVANIA STATE LINE TO HARRISBURG

The Chesapeake Bay Program research concluded that this area, located in the Piedmont phisiographic region, contributes a large percentage of the nonpoint source nutrient loading to the upper Chesapeake Bay. The greatest percentage of cropland in any Chesapeake Bay sub-basin is found here -- 38 percent of the land is used for crops. The area also supports a large number of cattle and other animals.

There have been many projects initiated in his sub-basin to address the conservation needs. These include the Mason Dixon Project, the Conestoga Headwaters Rural Clean Water Project, and a new study completed by the Pennsylvania Department of Environmental Resources entitled An Assessment of Agricultural Nonpoint Source Pollution in Selected High Priority Watersheds in Pennsylvania (June 1983). The programs were described in Section 1.

Continuous corn as a cropping system is used on about 25 percent of the cropland throughout the sub-basin. In general, this rotation is used on slopes of from 3 to 8 percent. Minimum tillage is used on 60 percent with the residue left, no-till planting on 10 percent with residue left, and conventional tillage practices on 30 percent with the residue removed. The average annual soil loss for this system is about 10 tons/ac/yr. The allowable soil losses ("T" values) average 4 tons/ac/yr.

A cropping system of corn, small grain, and hay is used on about 25 percent of the area. Corn, oats, wheat, and hay is used primarily in Schuylkill County on 70 percent of the cropland. Slopes of 3 to 12 percent are used for this rotation. Minimum tillage is used on about 80 percent with the crop residue left; conventional tillage is used on 20 percent with the residue removed. Average annual soil loss for this rotation is about 5 tons/ac/yr. The "T" values average about 3 to 4 tons/ac/yr.

Rotations with 2 years of corn, oats, or wheat, and 2 or more years of hay or 2 years of corn and 2 or more years of hay are devoted on about 60 percent of the area, particluarly where dairy farming is prevalent. These roatations occur on slopes of from 3 to 18 percent. Minimum tillage is used on about 75 percent with the residue left. Conventional tillage is used on 25 percent with residue left. The average annual soil loss is about 6 tons/acre. The "T" values average about 3 to 4 tons/acre.

Other specialty crops are substituted in the rotations on about 10 percent of the sub-basin. Tobacco is used in Lancaster County on about 30 percent of the cropland using 3 years of corn, tobacco, and winter small grains as a rotation. This rotation occurs on slopes of from 3 to 8 percent. About 80 percent of the rotation is minimum tillage with residues left and 20 percent is conventional tillage with residue removed. Tobacco is a conventional tillage row crop. The average annual soil loss is about 14 tons/ac/yr. The "T" values average about 4 tons/ac/yr.

Soybeans are grown in rotation, primarily in York County as a cash crop on about 75 percent of the cropland. In addition, small acreages of soybeans are grown in Adams and Dauphin Counties. Slopes vary from 3 to 8 percent. The cropping system of corn, small grain, and soybeans is generally minimum tilled with residues left. In some cases, winter small grain is seeded with the soybeans as a cover crop and left with the residue over winter. The average annual soil loss is about 6 tons/ac/yr. The "T" values average about 4 tons/ac/yr.

Animal units are evenly distributed within the sub-basin. The highest concentrations are in York and Lancaster Counties. The total amount of cattle in the sub-basin is about 346,900 animal units. Pigs amount to 342,700 units, and chickens to 9,489,000 units. Sheep and horses are concentrated in York and Lancaster Counties totaling 11,900 and 10,500, respectively. The turkey population is about 78,600 birds.

Terraces, grassed waterways, tile drainage, and contour strips are the most commonly applied conservation practices on land devoted to growing continuous corn and corn in rotation. Soil management practices followed include chisel plowing, minimum tillage on about 60 percent, and no-till on about 10 percent of the acreage cultivated for corn. About 30 percent of the corn grown is prepared by conventional plowing. Small grain, soybean, and hay crops are generally grown on land protected with contour strips, diversion, and tile drainage. Tobacco land is generally protected during the winter months with small grains or grass cover crops.

Conservation plans are needed in about 50 percent of the farms in the sub-basin. Greater efforts are needed to increase the amount of plans being completely followed above the current 15 percent. Although 70 percent of the conservation plans are partially followed, more effort needs to be directed toward raising the participation on these plans to an active status. The amount of conservation plans not being followed at all is anticipated to remain below the 15 percent level.

Agricultural land leased by farm operators accounts for about one third of the farmland devoted to crop production. Of this amount, about 10 percent is being farmed with conservation practices according to a conservation plan.

About 20 percent of the cropland is in need of grassed waterways, minimum tillage, no-till, contour strip-cropping, and conservation cropping systems to meet the T plus 5 level of soil loss. To achieve the T plus 2 soil loss level on the 25 percent of the cropland in need, practices including diversions, no-till, strip-cropping, tile drainage, grassed waterways, and conservation cropping systems are required. To achieve 60 percent of the cropland within the allowable soil loss ("T" value), terraces are needed in addition to all the above listed practices for treatment.

About 10 percent of the pastureland is in need of practices, including contour strip-cropping, tile drainage, grassed waterways, diversions, fencing, spring developments, watering facilities, and rotational grazing to achieve the T plus 2 level of soil loss reduction.

Approximately 60 percent of the animal units in the sub-basin are in need of animal waste management systems. Controls necessary for properly storing and handling the manure wastes include manure storage facilities and safe disposal of wastes.

Practices such as terraces, waterways, and diversions are needed to control surface runoff from waste disposal areas. In addition, management practices such as minimum or no-till farming, conservation cropping systems, and hay plantings are needed in the disposal area.

Feedlots present a special problem because of the heavy concentrated use by livestock. Measures such as fencing stream banks, diverting runoff with diversions, and safe water disposal from buildings are essential to control manure waste on feedlots.

In the future, the total acreage devoted to agriculture will decrease as more land is converted to developing areas. Hay and tobacco acreages are expected to decrease as more cropland is converted to increased corn, small grain, and soybean production. The intensification brought on by the double cropping will result in an increase of winter cover. The amount of farmland prepared by minimum tillage and no-till farming is expected to increase in this sub-basin to nearly 80 percent by the year 2000. The use of fertilizers and pesticides will increase with the use of conservation-tillage practices. The application of conservation practices such as terraces, grassed waterways, contour strip-cropping and animal waste systems are also expected to increase. There is a trend for increased acreage on fewer farms and an increased number of leased farmlands. Cattle number is expected to remain constant but will be concentrated in a smaller area. Swine, turkey, and chicken production is increasing.

A recent report (June 1983) was released by the Pennsylvania Department of Environmental Resources, Bureau of Soil and Water Conservation, entitled An Assessment of Agricultural Nonpoint Source Pollution in Selected High Priority Watersheds in Pennsylvania which proposed a number of recommendations for this area based on detailed studies. The following recommendations apply to ten small watersheds studied in the lower Susquehanna region. In general, soil conservation districts in these ten watersheds whould establish realistic time frames in which to accomplish the goals that are applicable to their watershed(s). They should seek the assistance of their cooperating agencies and/or private agricultural organizations to accomplish these goals.

To address the identified water quality problems associated with agricultural pollution, Conservation Districts should:

1. Establish a system to maintain an accounting of cooperators to show the status of conservation plans and plan implementation activities in each Conservation District. The system needs to record regular contracts and an updating of land-use activities. The use of a data management system utilizing computers should be considered.

2. Increase the rate of implementation of conservation plans, especially on rented land. Some of the most serious issues associated with implementation of plans and application of conservation practices are the problems associated with rented land. Following is a list of suggestions to improve the situation:

a. Long-term leases requiring conservation farming should be promoted and lists of owners and operators of rented land should be established for districts to facilitate the acceptance and use of leases.

b. A program explaining the economic and environmental benefits of conservation management should be addressed to both land-owners and the renting farmers.

c. Federal, state and local governments should consider providing tax incentives for conservation programs.

d. Additional conservation practice cost share incentives from state or Federal governments should be provided.

e. A cross-compliance program should be established whereby those farmers participating in either Federal or state assistance programs will be required to implement agricultural pollution control programs for the farm.

f. Local governments should be encouraged to enact and enforce ordinances for the prevention of off-site damages from accelerated erosion and uncontrolled runoff as authorized by the Clean Streams Act, Title 25, Department of Environmental Resources, Chapter 102, Erosion Control Rules and Regulations. this local involvement should augment the current regulatory program of the Department.

g. Land-owners who rent their land to farmers should be encouraged to select farmers who will implement best management practices.

3. Initiate a coordinated program to explain to farmers the benefits of conservation tillage. Tours, demonstration projects and no-till planter rentals are examples of initiates that could be undertaken.

4. Seek funding, in conjunction with DER, for increased technical assistance to implement the planning and installation of conservation practices. (The new matching grants to conservation districts through the state program contined in the 1981 Farm Bill authorizes the USDA to provide 15 to 25 percent of the grants to state conservation agencies for this purpose.)

5. Provide priority planning assistance to areas with either high soil loss and/or high concentration of livestock.

6. Work to improve stream banks with protective devices such as filter strips and maintenance of riparian vegetation. Owners and renters should be informed through various educational programs of low-cost methods to stabilize the banks and prevent pollutants from entering the water. Streams should also be protected from livestock access by means of offstream watering devices, stream fencing, or improved crossings.

7. Encourage the continuation of research on the development of soil-testing procedures, especially a reliable soil nitrogen test,

by the Pennsylvania State University so that more accurate and meaningful application recommendations can be provided to farmers.

8. Develop a nutrient management educational program as a joint effort of Conservation Districts, Pennsylvania Association of Conservation District Directors, Inc., Cooperative Extension Service, Soil Conservation Service, Agricultural Stabilization and Conservation Service, and Pennsylvania Department of Environmental Resources. This educational program, directed at farmers, should encourage balanced application of manure and/or commercial fertilizers. Manure, soil, and plant tissue testing should be used to achieve balanced application.

9. Encourage accelerated research on marketing and utilization of excess nutrients produced on farms. A potential exists to create a new industry through the marketing of these nutrients.

10. Pursue funding of a water testing program to determine the nature and extent of contaminants associated with agricultural activities.

Second Priority

1. Increase the percentage of cooperators in the ten high priority watersheds studied. Districts could facilitate this goal through activities such as personal visits, newsletters, and tours.

2. Explain farm management techniques that control erosion and nutrient losses by utilizing low-cost practices such as strip and contour cropping, winter cover, and green manure crops.

3. Promote the establishment of a higher cost share assistance program for animal waste handling and storage structures. The initial high costs of these practices and the public water quality benefits achieved justify the expenditure of such public funds.

4. Monitor construction of animal waste storage structures to prevent future ground-water pollution. Conservation districts should encourage local municipal governments to require inspection of these facilities and/or installation of monitoring wells when site conditions warrant.

5. Direct an information transfer program to mushroom growers, explaining the proper methods to dispose of spent mushroom soil to avoid runoff problems.

6. Initiate an educational program explaining renovation, maintenance, and runoff-control techniques for pasture improvement. New cost share incentives should be explored.

7. Promote the installation of stormwater control practices to protect livestock housing or loafing areas from runoff. Both technical and financial cost-share assistance should be provided to improve or relocate livestock housing or holding areas.

8. Promote expansion of the current educational program of the Cooperative Extension Service and the PA Department of Agriculture

to emphasize proper handling and application of herbicide and pesticide materials. Integrated pest management should be a part of the farmers' program.

While the conservation districts provide the catalyst to implementing the above recommendations at the local level, the Bureau of Soil and Water Conservation will incorporate these recommendations into its annual plan of operations for watershed and nonpoint agricultural programs. Priorities for implementing the recommendations will be based on the first priority recommendations, goals set by the conservation districts and water quality programs of the Department of Environmental Resources. Establishing a time frame for implementing each recommendation is difficult, since many of the recommendations are of a long-term nature requiring a continual educational process and many are also dependent on the involvement of one or more different agencies or organizations and their specific programs. It is the intent of the Bureau of Soil and Water Conservation to maintain regular contact with those agencies and organizations which have programs relative to the recommendations and to foster those programs based on the available resources of the Bureau.

In light of the results of the Chesapeake Bay Study and with similar results identified in this assessment, the Bureau of Soil and Water Conservation further recommends that this assessment process be continued in the high and medium priority watersheds identified in Pennsylvania's 208 Plan, especially the Susquehanna River Basin, to identify the specific farm management practices which have the potential for causing nonpoint source pollution. Also, new studies, as identified in the individual watershed reports, should be initiated to investigate the presentce and/or effects nutrients and pesticides may have on both surface and sub-surface water supplies as well as the cost benefits of conservation tillage and other best management practices.

## SUSQUEHANNA – HARRISBURG TO SUNBURY

The section of the Susquehanna sub-basin which lies between Sunbury and Harrisburg is physiographically in the Appalachian Ridge and Valley region. Coal mining is an important land-use activity. Cropland represents a high percentage (25.7 percent) of the land area. Pastureland is found on 5.7 percent of the land.

Continuous corn as a cropping system is used on about 15 percent of the cropland throughout the sub-basin. In general, this rotation is used on slopes of from 3 to 8 percent. Chisel plowing is used as a minimum tillage practice on areas with the crop residue removed. Minimum tillage accounts for about 60 percent of the corn acreage. No-till planting is used on about 10 percent with the residue left. Conventional tillage practices are used on 30 percent with the residue removed. The average annual soil loss of this system is about 8 tons/ac/yr. The allowable soil losses ("T" values) average 3 to 4 tons/ac/yr.

Cropping systems of corn, oats, wheat, and hay or corn, small grain, and hay are used on about 15 percent of the area. Slopes of 3 to 12 percent are used for these rotations. Minimum tillage is used on about 75 percent with the crop residue left. Conventional tillage is used on 25 percent with the residue left. Average annual soil loss for these rotations is about 5 tons/ac/yr. The "T" values average about 3 to 4 tons/ac/yr.

Rotations with two years of corn, oats, or wheat, and two or more years of hay or two years of corn, and two or more years of hay are devoted on about 60 percent of the area, particularly where dairy farming is prevalent. These rotations occur on slopes of from 3 to 18 percent. Minimum tillage is used on about 75 percent with the residue left. Conventional tillage is used on 25 percent with residue left. The average annual soil loss is about 6 tons/ac/yr. The "T" values average about 3 to 4 tons/ac/yr.

Other specialty crops are substituted in the rotations on about 10 percent of the sub-basin. Cabbage, potatoes, and small grain are grown in rotation primarily in Schuylkill County. This rotation occurs on slopes 3 of from to 15 percent. Conventional tillage with residue removed is used with this rotation. The average annual soil loss is about 6 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Generally, soybeans are grown as a cash crop in rotation with corn, small grain, soybeans or with corn, soybeans, wheat, and hay with minimum tillage and residue left. Slopes vary from 3 to 15 percent. In some cases, winter small grain is seeded with the soybeans as a cover crop and left with the residue over winter. The average annual soil loss is about 12 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Animal units are evenly distributed within the sub-basin. The total amount of cattle in the sub-basin is about 152,300 animal units. Pigs amount to 78,100 units and chickens to 1,414,200 units. Sheep and horses totaling 13,200 and 2,600, respectively are located within the sub-basin. The turkey population is about 75,800 birds.

Terraces, grassed waterways, tile drainage, and contour strips are the most commonly applied conservation practices on land devoted to growing continuous corn and corn in rotation. Soil management practices followed include chisel plowing, minimum tillage on about 60 percent, and no-till on about 10 percent of the acreage cultivated for corn. About 30 percent of the corn grown is prepared by conventional plowing. Small grain, soybean, and hay crops are generally grown on land protected with contour strips, diversions, and tile drainage. Cabbage and potato acreage is generally farmed using winter small grain, grassed waterways, and contour strip-cropping for protection.

Conservation plans are needed in about 40 percent of the farms in the sub-basin. Greater efforts are needed to increase the amount of plans being completely followed above the current 20 percent. Although 75 percent of the conservation plans are partially followed, more effort needs to be directed toward raising the participation on these plans to an active status. The amount of conservation plans not being followed at all is anticipated to remain below the 15 percent level.

Agricultural land leased by farm operators accounts for about 30 percent of the farmland devoted to crop production. Of this amount, about 20 percent is being farmed with conservation practices according to a conservation plan.

About 25 percent of the cropland is in need of grassed waterways, minimum tillage, no-till, contour strip-cropping, and conservation cropping systems to meet the T plus 5 level of soil loss. To achieve the T plus 2 soil loss level on 50 percent of the cropland in need, practices including diversions, no-till, strip-cropping, tile drainage, grassed waterways, and conservation cropping systems are required. To obtain 75 percent of the cropland within the allowable soil loss ("T" value), terraces are needed in addition to all the above listed practices for treatment.

Less than 10 percent of the pastureland is in need of conservation practices, including contour strip-cropping, tile drainage, grassed waterways, diversions, fencing, spring developments, watering facilities, and rotational grazing to achieve the T plus 2 level of soil-loss reduction. In addition, less than 10 percent of the pasture is in need of management practices to meet the "T" allowable soil loss level.

Approximately 60 percent of the animal units in the sub-basin are in need of animal waste management systems. Controls necessary for properly storing and handling the manure wastes include manure storage facilities and safe disposal of wastes.

Practices such as terraces, waterways, and diversions are needed to control surface runoff from waste disposal areas. In addition, management practices such as minimum or no-till farming, conservation cropping systems, and hay plantings are needed in the disposal area.

Feedlots present a special problem because of the heavily concentrated use by livestock and their close proximity to water courses. Measures such as fencing stream banks, diverting runoff with diversions, safe water disposal from buildings, rock riprap along stream banks, grass borders and filter strips along streams, holding ponds, lagoons, and relocation of facilities are essential to control manure waste on feedlots.

The outlook for the future is for an increased application of conservation practices, including the use of terraces, minimum and no-till farming, grassed waterways, winter cover, and contour strip-cropping. As corn and small grain production increases, hay-land area is expected to drop.

While the total acreage devoted to agriculture will decrease as more land is converted to developing areas, the average size of each farm is increasing as farms consolidate. The trend toward leasing of farmland on a short-term basis will be accompanied by a decrease in application of conservation practices on these lands. The total number of cattle is expected to remain constant and will be in fewer herds with larger numbers of animal units per herd. Meanwhile, production of swine, chickens, and turkeys is on the increase. Installation of animal waste systems is increasing.

Future use of fertilizer is expected to increase with more phosphate fertilizers used for grain crops, and a rapid increase in the use of nitrogen fertilizer resulting from increased use of no-till farming methods. Use of pesticides will increase proportionately to the increase in no-till farming.

## SUSQUEHANNA-JUNIATA BRANCH

The Juniata sub-basin lies in the Appalachia Ridge and Valley physiographic region. Continuous corn as a cropping system is used on about 20 percent of the cropland throughout the sub-basin. In general, this rotation is used on slopes from 2 to 10 percent. Minimum tillage with residue left is used on about 50 percent of the corn acreage. Chisel plowing is used increasingly for minimum tillage. The average annual soil loss for minimum tillage of continuous corn is about 5 tons/ac/yr. The average allowable soil loss ("T" value) for this land is 4 tons/ac/yr. Conventional tillage practices are used on 50 percent of the cropland with the residue removed. The average annual soil loss for this system is about 10 tons/ac/yr. The "T" values average 4 tons/ac/yr.

The cropping system of corn, oats or wheat, and hay is used on about 20 percent of the area. Individual crop sequences vary from corn, oats, and hay to two years of corn, and oats, and two years or more of hay. Slopes of 3 to 15 percent are used for this rotation. Conventional tillage is commonly used with the residue removed. Average annual soil loss is about 5 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Cropping systems using corn and hay are common on about 60 percent of the area. Crop sequences vary from one year of corn and one year of hay to four years of corn and four years of hay. These rotations occur on slopes of from 3 to 18 percent. Conventional tillage is used on about 50 percent with the crop residue removed. The average annual soil loss is about 8 tons/ac/yr. The "T" values average about 3 tons/ac/yr. Minimum or no-till farming is used on the remaining 50 percent of the cropland with residues left. The average annual soil loss for this tillage is 3 tons/ac/yr. The "T" values average about 3 to 4 tons/ac/yr.

Animal units are evenly distributed within the sub-basin. The total amount of cattle in the sub-basin is about 130,000 animal units. Pigs amount to 45,000 units and chickens to 1,582,000 units. Sheep and horses totaling 6,000 and 1,800, respectively are located within the sub-basin.

Diversions, grassed waterways, tile drainage, and contour strip-cropping are the most commonly applied conservation practices on land devoted to growing continuous corn and corn in rotation. Small grain and hay crops are generally grown on land protected with contour strip-cropping, diversions, and tile drainage.

Conservation plans are needed in about 50 percent of the farms in the sub-basin. Greater efforts are needed to increase the amount of plans being completely followed above the current 20 percent. Although 65 percent of the conservation plans are partially followed, more effort needs to be directed toward raising the participation on these plans to an active status. The amount of conservation plans not being followed at all is anticipated to remain below the 12 percent level.

Agricultural land leased by farm operators accounts for about 25 percent of the farmland devoted to crop production. Of this amount, about 30 percent is being farmed with conservation practices according to a conservation plan.

About 12 percent of the cropland is in need of grassed waterways, minimum tillage, no-till, contour strip-cropping, and conservation cropping systems to meet the T plus 5 level of soil loss. To achieve the T plus 2 soil-loss level on the 30 percent of the cropland in need, practices including diversions, no-till, strip-cropping, tile drainage, grassed waterways, and conservation cropping systems are requried. To achieve 50 percent of the cropland within the allowable soil loss ("T" value), terraces are needed in addition to all the above listed practices for treatment. Less than 10 percent of the pastureland is in need of fertility and reseeding practices to meet the T plus 2 and "T" allowable soil loss.

Approximately 45 percent of the animal units in the sub-basin are in need of animal waste management systems. Controls necessary for properly storing and handling the manure wastes include manure storage facilities and safe disposal of wastes.

Practices such as terraces, waterways, and diversions are needed to control surface runoff from waste disposal areas. In addition, management practices such as minimum or no-till farming, conservation cropping systems, and hay plantings are needed in the disposal area.

Looking to the future, the trend is for a decrease in acreage devoted to agriculture. Hay and small grain acreage is decreasing while corn acreage is increasing. Cropping systems will become more intensified with row crops. The average size of farm acreage is increasing as is the number of leased farmlands. Fewer cattle herds are anticipated with larger numbers of animal units per herd.

The application of conservation practices, including diversions, minimum and no-till practices, grassed waterways, contour strip-cropping and installation of animal waste systems is on the increase. More farmers will leave crop residues on their fields over winter, and the use of fertilizers and pesticides will increase as conservation tillage practices are more widely used.

## SUSQUEHANNA – WEST BRANCH

The West Branch of the Susquehanna River encompasses both Appalachian Ridge and Valley, and Appalachian Plateau physiographic features. It is the most forested of all Susquehanna sub-basins, and contains the least amount of cropland (8.7 percent) due to the steeper slopes. Coal mining is prevalent.

Continuous corn as a cropping system is used on about 10 percent of the cropland through the sub-basin. In general, this rotation is used on slopes of from 0 to 18 percent. Chisel plowing is used as a minimum tillage practice on areas with the crop residue removed. Minimum tillage accounts for about 80 percent of the corn acreage with residue left. Conventional-tillage practices are used on 20 percent of the acreage with the residue removed. The average annual soil loss of this system is about 12 tons/ac/yr. The allowable soil losses ("T" values) average 4 tons/ac/yr.

A cropping system of two or more years of corn, and three or more years of hay are used on about 15 percent of the area. Slopes of 0 to 15 percent are used for this rotation. The average annual soil loss of this system is about 6 tons/ac/yr. The allowable soil losses ("T" values) average 3 tons/ac/yr.

Cropping systems with two years of corn, oats, or wheat, and two or more years of hay are used on about 70 percent of the area, particularly where dairy farming is prevalent. These rotations occur on slopes of from 3 to 15 percent. Conventional tillage is used with the residue removed. The average annual soil loss of this system is about 6 tons/ac/yr. The allowable soil losses ("T" values) average 3 tons/ac/yr.

Other specialty crops are substituted in the rotations on about 5 percent of the sub-basin. A rotation of one or two years of potatoes and oats are grown primarily in Potter and Cambira Counties. These rotations occur on slopes 0 to 10 percent. Conventional tillage is used with residues left. Rye is used as a cover crop where residues are removed. The average annual soil loss of this system is about 6 tons/ac/yr. The allowable soil losses ("T" values) average 3 tons/ac/yr.

Some soybeans are used in Lycoming, Montour, and Northumberland Counties as an alternative cash crop for corn in the rotations. Generally, crop sequences include corn and/or soybeans, oats, wheat, and four years of hay in Lycoming County; corn, soybeans, oats, and hay in Montour County; and corn, small grain, and soybeans in Northumberland County. Slopes vary from 0 to 10 percent. In some cases, winter small grain is seeded with the soybeans as a cover crop and left with the residue over winter. The average annual soil loss is about 8 tons/ac/yr. The allowable soil losses ("T" values) average 3 tons/ac/yr.

Animal units are evenly distributed within the sub-basin. The total amount of cattle in the sub-basin is about 104,300 animal units. Pigs amount to 42,600 units and chickens to 431,500 units. Sheep and horses totaling 7,300 and 3,200, respectively are located within the sub-basin.

Diversions, grassed waterways, tile drainage, and contour strip-cropping are the most commonly applied conservation practices on land devoted to growing continuous corn and corn in rotation. Small grain, soybean, and hay crops are generally grown on land protected with contour strip-cropping, diversions, and tile drainage. Potato acreage is generally farmed using winter small grain, grassed waterways, and contour strip-cropping for protection.

Conservation plans are needed in about 45 percent of the farms in the sub-basin. Greater efforts are needed to increase the amount of plans being completely followed above the current 15 percent. Athough 70 percent of the conservation plans are partially followed, more effort needs to be directed toward raising the participation on these plans to an active status. The amount of conservation plans not being followed at all is anticipated to remain below the 10 percent level.

Agricultural land leased by farm operators accounts for about 30 percent of the farmland devoted to crop production. Of this amount, about 35 percent is being farmed with conservation practices according to a conservation plan.

About 15 percent of the cropland is in need of grassed waterways, minimum tillage, contour strip-cropping, and conservation cropping systems to meet the T plus 5 level of soil loss. To achieve the T plus 2 loss level on the 30 percent of the cropland in need, practices including diversions, strip-cropping, tile drainage, grassed waterways, and conservation cropping systems are required. To achieve 60 percent of the cropland within the allowable soil loss ("T" value), terraces and no-till farming are needed in addition to all the above listed practices for treatment.

Approximately 60 percent of the animal units in the sub-basin are in need of animal waste management systems. Controls necessary for properly storing and handling the manure wastes include manure storage facilities and safe disposal of wastes.

Practices such as terraces, waterways, and diversions are needed to control surface runoff from waste disposal areas. In addition, management practices such as minimum or no-till farming, conservation cropping systems, and hay plantings are needed in the disposal area.

Feedlots present a special problem because of the heavily concentrated use by livestock and their close proximity to water courses. Measures such as fencing stream banks, diverting runoff with diversions, safe water disposal from buildings, rock riprap along stream banks, grass borders and filter strips along streams, holding ponds, lagoons, and relocation of facilities are essential to control manure waste on feedlots.

In the future, the total acreage devoted to agriculture will decrease as more land is converted to development. In Clearfield County, widespread strip-mining is occurring, which returns only 15 percent of the land to cropland. Small grain and hay acreage is expected to decrease as corn, vegetable, and soybean production increases. Cropping systems will become more intensified with row crops, and farmers will leave crop residues on their fields over winter. The increased use of rye as a winter cover for vegetable crops is anticipated.

With the increase in no-till, farming, there will be an increase in the use of fertilizers and pesticides. Total use of phosphate fertilizer will increase, especially for grain crops, but not as rapidly as use of nitrogen.

Farming operations are becoming more specialized. Chicken, cattle, sheep, and horse production is expected to remain constant, though the trend will be for larger numbers in fewer locations. Swine production is decreasing.

There is a trend toward leasing of farmland. These lands are therefore less likely to keep pace with the application of conservation practices since operators are unable to recover their investment.

The number of actively followed conservation plans is decreasing though the application of conservation practices, such as use the of diversions, minimum and no-till methods, grassed waterways, contour strip-cropping, and installation of animal waste systems, will increase.

## SUSQUEHANNA – MAIN STEAM ABOVE SUNBURY

Of all Susquehanna sub-basins, this section in the Appalachia Plateau physiographic region contains the highest percentage of pastureland (9.7 percent); 16.7 percent of the land is devoted to crops.

Continuous corn as a cropping system is used on about 15 percent of the cropland throughout the sub-basin. In general, this rotation is used on slopes of from 3 to 10 percent. Minimum tillage with residue left is used on about 50 percent of the corn acreage. Chisel plowing is used increasingly for minimum tillage. The average annual soil loss for minimum tillage of continuous corn is about 5 tons/ac/yr. The average allowable soil loss ("T" value) for this land is 3 tons/ac/yr. This minimum-tillage system is used more commonly in the lower portion of the sub-basin. Conventional tillage practices are used on the remaining 50 percent of the cropland with the residue removed. The average annual soil loss for this system is about 12 tons/ac/yr. The "T" values average 3 tons/ac/yr. This type of tillage is most commonly used in the upper reaches of the sub-basin.

A cropping system of corn, small grain, and hay is used on about 40 percent of the area. Individual crop sequences vary from corn, oats, and hay to two years of corn, and oats, and four years of hay. Slopes of from 3 to 20 percent are used for this rotation. Minimum tillage is used on about 20 percent with the crop residue left. Conventional tillage is commonly used on 80 percent with the residue removed. Average annual soil loss for this rotation is about 5 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Cropping systems using corn and hay are common on about 35 percent of the area. Crop sequences vary from one year of corn and one year of hay to four years of corn and four years of hay. These rotations occur on slopes of from 3 to 18 percent. Minimum tillage is used on about 25 percent and conventional tillage on 75 percent. The residue is removed on about 40 percent and left on 60 percent of the cropland. The average annual soil loss is about 7 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Other specialty crops are substituted in the rotations on less than 10 percent of the sub-basin. Cabbage, potatoes, and tomatoes are grown in rotations of vegetable, small grain, and hay primarily in Luzerne and Schuylkill Counties. This rotation occurs on slopes of from 3 to 10 percent. Conventional tillage with residue removed is used on about 80 percent. The average annual soil loss is about 7 tons/ac/yr. The "T" values average about 3 tons/ac/yr.

Animal units are evenly distributed within the sub-basin. The total amount of cattle in the sub-basin is about 165,200 animal units. Pigs amount to 33,600 units and chickens to 730,000 units. Sheep and horses totaling 6,000 and 7,700, respectively are located within the sub-basin.

Diversions, grassed waterways, tile drainage, and contour strip-cropping are the most commonly applied conservation practices on land devoted to growing continuous corn and corn in rotation. Small grain and hay crops are generally grown on land protected with contour strip-cropping, diversions, and tile drainage. Vegetable crops are generally farmed on land protected by contour farming, strip-cropping, and tile drainage.

Conservation plans are needed in about 35 percent of the farms in the sub-basin. Greater efforts are needed to increase the amount of plans being completely followed above the current 25 percent. Although 60 percent of the conservation plans are partially followed, more effort needs to be directed toward raising the participation on these plans to an active status. The amount of conservation plans not being followed at all is anticipated to remain below the 20 percent level.

Agricultural land leased by farm operators accounts for about 30 percent of the farmland devoted to crop production. Of this amount, about 50 percent is being farmed with conservation practices according to a conservation plan.

About 20 percent of the cropland is in need of grassed waterways, minimum tillage, contour strip-cropping, and conservation cropping systems to meet the T plus 5 level of soil loss. To achieve the T plus 2 loss level on the 40 percent of the cropland in need, practices including diversions, strip-cropping, tile drainage, grassed waterways, and conservation cropping systems are required.

To achieve 60 percent of the cropland within the allowable soil loss ("T" value), terraces and no-till farming are needed in addition to all the above listed practices for treatment.

Less than 10 percent of the pasture is in need of diversions, grassed waterways, fencing, tile drainage, and watering facilities to meet the T plus 2 and "T" allowable soil loss.

Approximately 60 percent of the animal units in the sub-basin are in need of animal waste management systems. Controls necessary for properly storing and handling the manure wastes include manure storage facilities and safe disposal of wastes.

Practices such as terraces, waterways, and diversions are needed to control surface runoff from waste disposal areas. In addition, management practices such as minimum or no-till farming, conservation cropping systems, and hay plantings are needed in the disposal area.

Feedlots present a special problem because of the heavily concentrated use by livestock and their close proximity to water courses. Measures such as fencing stream banks, diverting runoff with diversions, safe water disposal from buildings, rock riprap along stream banks, grass borders and filter strips along streams, holding ponds, lagoons, and relocation of facilities are essential to control manure waste on feedlots.

The trend for the future is for a decrease in agricultural land as land is converted to developing areas. There is an increase in the number of leased framlands. Hay-land acreage is expected to drop while land in corn, small grain, vegetables, and soybean production is on the increase. More farmers will leave crop residues on their fields over winter as the use of minimum and no-till methods increase. Winter small grains will provide more winter cover as they will be used in the rotation of crops.

With the increase in no-till farming will be an increase in the use of fertilizers and pesticides. The use of nitrogen fertilizer is expected to increase rapidly. Total use of phosphate fertilizer will increase, especially for use on grain crops.

There will be no significant changes in livestock numbers, though the trend will be for concentration of animals in larger groups.

The number of actively followed conservation plans is decreasing, though the application of conservation practices, such as the use of diversions, minimum and no-till methods, grassed waterways, contour strip-cropping and installation of animal waste systems, will increase.

## SUSQUEHANNA AND BUSH RIVERS

This drainage area includes both the Bush River basin in Harford County and those portions of Harford and Cecil Counties which drain into the Susquehanna and upper Chesapeake Bay. Octoraro Creek in Cecil County drains a portion of Lancaster and Chester Counties in Pennsylvania. Conservation-tilled continuous corn is grown on approximately 35 percent of the cropland in these watersheds. Most of this corn is planted on slopes of from 3 to 8 percent, but some is planted on land with slopes of up to 15 percent. Average soil losses are from 4 to 8 tons/ac/yr, but losses can be as high as 11 tons. Very little land in these watersheds is conventionally tilled. Double cropping of corn, small grain, and soybeans is practiced in the Maryland portion on about 20 percent of the land. Rotations containing hay are practiced in these watersheds on 20 percent of the land and are usually one or two years of corn followed by small grain, and then 3 to 5 years of hay. Soil losses with this rotation generally meet the tolerable loss of 4 tons/ac/yr.

Animal populations are not evenly distributed throughout the watersheds. Only 6,000 head of cattle are in the Connowingo to the Havre-de-Grace drainage area of the Susquehanna and 4,500 in the Bush River sub-basin; the segment of the Susquehanna in Pennsylvania from Columbia, Pa. to Connowingo has many more cattle. Typically, the conservation practices in place are grassed waterways, diversions, strip-cropping, winter cover, and conservation tillage.

About 75 to 80 percent of the farmers in these sub-basins have plans. Statistics on implementing the plans vary between Harford and Cecil Counties. Only about 15 percent of the farmers in Cecil County have fully implemented plans, whereas 50 percent are implementing them in Harford County. About 15 percent are not followed at all. The farmers are leasing about 35 percent of their cropland.

Cropland in this region needs more of the same practices the farmers are presently applying, including conservation tillage, diversions, strip-cropping, waterways, animal waste management systems, spring developments, and fencing.

Pastureland is scattered throughout the watershed but more and more operations are converting to confined feedlots. Emphasis needs to be given to locating new feedlots away from streams and diverting and treating the runoff, if necessary, before discharging it into the streams.

Future trends in this segment include a gradual decrease in the number of farms due to a moderate pressure from the urban segment. Cropping systems will intensify greatly and many of the dairy operations will change to the raising of feed grains. With this conversion will come an increase in the amount of land in conservation tillage with a corresponding increase in the use of fertilizer and pesticides. Equipment size will also increase, bringing on a decrease in some of the conservation practices already in place.

## WEST CHESAPEAKE, PATAPSCO, JONES FALLS, GUNPOWDER, AND BACK RIVERS

These watersheds along the western shore of Maryland are all experiencing moderate to heavy pressures of urbanization from either the Baltimore or Washington metropolitan areas. As in other watersheds experiencing these pressures, the tendency of the farmer is to intensify his cropping system. He is forced to lease land at high rent values and feels agriculture is insecure in the region. This feeling of impermanance leads to less conservation of the land.

Continuous corn with minimum tillage and residues left after harvesting is the dominant cropping system in the West Chesapeake and Patapsco basins. This cropping system is used on 45 percent of the cropland in these watersheds, whereas it is followed on only 20 percent of the cropland in the Gunpowder basin. The slope of the land on which this rotation is practiced is generally from 5 to 15 percent with the resulting soil losses ranging from 5 to 10 tons/ac/yr and averaging 6 to 7 tons. The tolerable limit is 3 to 4 tons. Double-cropped corn, small grain, and soybeans are grown on approximately 15 percent of the cropland in the West Chesapeake and Patapsco, whereas it occupies about 50 percent of the cropland in the Gunpowder. With this rotation, the soil losses are in the range of 5 to 6 tons/ac/yr, which is still above the allowable 4 tons. Other rotations include the following: corn, small grains, followed by 2 to 4 years of hay under conventional tillage on 25 percent of the land in the Patapsco, yielding 5 to 7 tons of soil loss; tobacco under conventional tillage on 35 percent of the cropland in the West Chesapeake, yielding 12 tons of soil loss and truck crops on less than 10 percent of the cropland in the Patapsco and Gunpowder, yielding soil losses of from 6 to 10 tons/ac/yr.

The animal distribution in these watersheds is insignificant except in the upper reaches of the Patapsco in Carroll County. Even there the density of livestock is not significant.

Conservation practices applied in these watersheds are limited to conservation tillage and cover crops with limited amounts of grassed waterways, cross slope farming, strip-cropping, and drainage on the flatter slopes.

Fifty percent of the farmers in the Gunpowder and Patapsco watersheds have conservation plans. Of these, approximately 10 percent follow them completely and 20 percent do not follow them at all. In the West Chesapeake, however, only 40 percent have plans, but 25 percent are following them entirely. Here again, 10 percent do not follow them at all.

Leasing of land is commonplace in the Gunpowder and Patapsco watersheds with the farmers leasing approximately 40 percent of the land they operate. In contrast, only 15 percent of the cropland is leased in the West Chesapeake. Even here, however, competition is keen between the farmer and the developer.

A need exists to apply more conservation on the land. This intensively-cropped land needs more conservation tillage, waterways, diversions, and strip-cropping to meet tolerable soil losses.

Pastureland and animal waste are of no signifance in the West Chesapeake basin. In the Patapsco and Jones Falls basins, as in the Gunpowder and Bush basins, the concern is in the upper reaches in Carroll and Harford Counties. Here, animal waste management systems, spring developments, pasture and hay-land planting and management, livestock watering facilities, and fencing are needed.

Future trends in these watersheds will be continued pressure on the agricultural land from the urbanizing activities. Again, it is difficult to predict how much agriculture will remain in these watersheds by the year 2000. What remains will be small patch farming or highly mechanized cash grain farming that relies heavily on leased land. Pesticide and fertilizer use will increase as more land is converted to conservation tillage.

## CHESTER, SASSAFRAS, AND ELK RIVERS

The upper Eastern Shore varies from the lower shore in that the topography is more varied. Average slopes in these basins range up to 8 percent, resulting in more erosion on the intensively-cropped fields. Although drainage is an important practice in the Chester, it is relatively insignificant in the other two watersheds. Erosion control and animal waste management are more significant.

Noteworthy in the Elk watershed is a special Agricultural Conservation Program (ACP) project on Little Northeast Creek. The project has accelerated funding to control sediment and runoff from animal waste. Of concern, however, is the farmer's inability to contribute his share of the cost.

Continuous corn with conservation tillage and the residues left is grown on about 20 percent of the cropland in these watersheds. With the slopes of up to 8 percent, soil losses range from 5 to 8 tons/ac/yr compared to a tolerable level of 3 to 4 tons. Corn and soybeans are grown on an additional 30 percent of the cropland, utilizing conservation tillage and leaving the residues. The soil losses and tolerable limit with this cropping system are approximately the same as for continuous corn. Forty percent of the cropland is double-cropped, with corn followed by small grain and then soybeans in the second year. Soil losses with this system vary from 4 to 6 tons/ac/yr compared to the tolerable level of 3 to 4 tons. The remaining cropland is either in conventional-tilled corn or soybeans, or in a rotation of one or two years of corn followed by 3 to 5 years of hay. Soil losses with these cropping systems would be 8 and 2 tons/ac/yr, respectively.

The number of livestock are not significant in the Chester basin but are significant in the Sassafras and Elk. Animal distribution is uniform by watershed, but density increases in the Sassafras and is more dense in the Elk.

In addition to a preference for conservation tillage, most farms have ponds for livestock water. Drainage ditches and sub-surface drains have been installed in the poorly-drained soils to render them suitable for cropping. Other common practices include grassed waterways, contour and cross-slope farming, contour and field strip-cropping, diversions, critical area planting, spring development, rotation grazing, pasture and hay-land planting and management, and animal waste management systems.

Sixty percent of the farms in the Chester watershed have conservation plans, whereas 80 percent in the Sassafras and Elk watersheds have plans. In all three watersheds, about one-fifth of those having plans do not follow them at all and only 10 to 15 percent follow them completely. The remaining plans are in various stages of implementation.

Farmers in these watersheds are leasing about one-third of the land they crop. In general, there is not a conservation plan on leased land and it is farmed more intensively than the land farmers own. Soil losses on this land would be 2 to 3 tons per acre higher than the land they own.

Needed practices are more of the same that have already been installed. Emphasis needs to be placed on conservation tillage, diversions, waterways, strip-cropping, spring development, and animal waste management systems. Animal access to streams and the close proximity of feedlots and barns to streams presents a problem that is difficult and expensive to correct.

Future trends in these watersheds will be a continued conversion from dairy herds to cash grain farming. Increased double-cropping of corn, small grains, and soybeans will be significant. Equipment size will increase, as will the use of fertilizer and pesticides. The acreage operated by farmers will increase with a heavy reliance on leased land. Irrigation, fertigation, and drainage will increase in the Chester River basin.

## LOWER EASTERN SHORE, INCLUDING THE POCOMOKE, NANTICOKE, AND CHOPTANK RIVERS, AND EASTERN BAY

The lower Eastern Shore of Maryland is characterized by low-lying land and intensive farming. Lack of drainage is the major conservation problem and locating and constructing suitable drainage outlets is the major concern. The majority of the cropland is on flat terrain with slopes of only 1 to 2 percent. Erosion, therefore, is not of major concern and predicted soil losses are only from 1 to 3 tons/ac/yr. The coarse fragments and even some of the fine-particle sediments are normally settled out in the ditches before they reach the Bay.

Corn and soybeans are the dominant crops in these watersheds. Minimum tillage is rapidly gaining acceptance on the land suited for it. Its use is widespread on the well-drained soils but limited on the poorly-drained soils. This is due to the fact that the surface litter shades the cold wet soil, preventing it from warming up in the spring and thus delaying germination. Approximately 45 percent of the land is in a corn and soybean rotation, utilizing conservation tillage and leaving the residues. Another 30 percent of the land is in the same rotation with conventional tillage. Double-cropping of corn, small grains, and soybeans using conservation tillage is practiced on an additional 20 percent of the land. The remaining 10 percent of the land is in truck crops or in a rotation of soybeans and small grains. Soil loss is not of concern. Even the most intense rotations are within the tolerable limits, having soil losses of only 3 tons/ac/yr.

Livestock numbers are small in these watersheds and should not be considered as a source of pollution. There are, however, poultry and hog operations which, in localized situations, can cause animal waste problems. Nitrate pollution to ground-water from these operations needs to be of particular concern.

The principal conservation practice applied on the lower shore is drainage, both open ditch and sub-surface drains. Many ponds have also been constructed for irrigation, recreation, and for fish and wildlife. Field borders and vegetative buffer strips have also been planted to prevent sediment from entering the drainage system.

Seventy to seventy-five percent of the more than 2,700 farms in these watersheds have conservation plans. Ninety percent of these plans are at least partially applied with figures varying widely as to how many are followed entirely.

The farm units here are also growing in size to remain economically competitive and, therefore, there is a need to lease land. It is estimated that approximately 40 percent of the cropland is leased. Since this land is flat, the leased land does not cause the sediment problems as is evidenced in the Piedmont and in the rolling, hilly, or mountainous land.

As discussed earlier, the main conservation needs are drainage and the vegetative filter strips associated with the ditches. Additional practices needed are conservation tillage, windbreaks, and cover crops. Irrigation is becoming more widespread and its use will continue to expand.

Pastureland is sparse due to the few number of livestock, but animal waste structures and systems are needed for the hog and poultry enterprises. The number of broilers and hogs continues to increase.

It is expected that there will be a continuing emphasis on drainage in these watersheds to improve cropland. With drainage, the cropping systems will intensify, and more filter strips will be applied to prolong the useful life of the ditches. Other future trends include larger farm equipment and increased amounts of fertilizer and pesticides used as farmers in these watersheds convert to more conservation tillage. Irrigation and fertigation will also increase. The size of farming operations will also increase with more reliance on leased land.

## PATUXENT – UPPER BASIN

This segment lies in the Piedmont physiographic region. As in the Little Falls to Woodbridge segment of the Potomac, this segment is experiencing rapid urban growth and tremendous pressure exists to convert agricultural land to non-farm uses. Here too, the farmer is forced to lease from speculators and developers rather than from retired farmers.

Approximately 75 percent of the cropland is in continuous corn. Conservation tillage is followed on all of this land with the exception of about 10 percent planted by conventional tillage with the residues left. One fourth of the continuous corn acreage is harvested for silage, followed by a fall cover crop planted by conservation tillage. About 10 percent of the cropland planted to continuous corn has the residues removed and no cover crop planted over the winter. Other rotations cover the remaining 25 percent of upper basin cropland and consist of one year each of corn and small grain followed by 2 to 4 years of hay; a two year rotation of corn followed by small grain, and a rotation of 2 to 3 years of soybeans, followed by 2 to 3 years of hay.

Cropland slopes vary from 3 to 15 percent with approximately half being in the 3 to 8 percent range and the other half being in the 8 to 15 percent range. The more intensive cropping systems tend to be on the flatter slopes. Average soil loss runs from 5 to 7 tons/ac/yr for all rotations except the conventional-tilled corn, residues left, and conservation-tilled corn, residues removed. These systems yield a soil loss of 20 to 22 tons/ac/yr. The tolerable soil losses range from 3 to 4 tons/ac/yr.

Few animals remain in this portion of the watershed in Montgomery County; those that do are concentrated in the extreme upper portion of the watershed. Likewise, in Howard County, the animal density increases in the upper portion of the watershed. The primary conservation practices used are conservation tillage and grassed waterways with limited strip-cropping in Howard County. Forty to forty-five percent of the farms have conservation plans but, as in the other urban areas, they are extremely out-of-date. This is reflected by the fact that only about 10 percent of them are followed in their entirety. Eighty percent of the farmers are following the plans to varying degrees.

Leased land plays a major role in these two counties, supplying about 60 percent of the cropland farmers use. Again, the leases are short-term and the price is high. The only practice applied to this land is conservation tillage but, occasionally, natural drainage-ways are left in sod.

Needed on cropland are rotations that include hay, strip-cropping, diversions, and waterways. On the limited pasture acreage, rotation grazing and spring developments are needed. Animal waste management systems are needed on most of the dairy farms in Howard County but only on a limited number in Montgomery County.

Future trends in this segment will be for a continued pressure on agricultural land from developers and speculators. It is difficult to speculate as to whether there will be any agriculture remaining by the year 2000 other than isolated farms. The few farms remaining will be highly automated, relying heavily on leased land. Herbicide and fertilizer use will increase as this land is converted to more conservation tillage.

## PATUXENT – LOWER BASIN

In contrast to the upper portion of the watershed, this river segment consists entirely of soils of the coastal plain. It is the heart of the tobacco industry in Maryland, growing approximately 50 percent of the state's tobacco. The remaining 50 percent is also grown in southern Maryland but in that portion draining to the Potomac.

Although tobacco is not the major crop of the area, it has high average soil losses and therefore is significant. Of importance is the fact that chemicals are not presently available for the tobacco farmer to apply conservation tillage. Thus, the only way to reduce the losses is to construct the more expensive engineering practices or to take land out of production. Unfortunately, many of these farmers own limited acreage and need all of their land for production. In addition, the majority of these farmers find it necessary to work off the farm to supplement income. Tobacco is grown on 30 percent of the cropland in this river segment. It is conventionally tilled and a cover crop is planted on virtually all of the acreage. The tobacco is rotated with small grains when land is available.

Continuous corn is grown on about 50 percent of the cropland in this segment. Conservation tillage is widely accepted and virtually all of the continuous corn is planted in this manner. Approximately 15 percent of the corn is in a 2-year rotation with soybeans, with both crops planted by conventional tillage. The remaining cropland is either double-cropped corn, small grain and soybeans, or continuous soybeans.

The average slopes on cropland in this segment are from 6 to 8 percent. This, coupled with the intensity of the cropping systems, results in soil losses ranging from 5 to 20 tons/ac/yr. The higher figures are, for the most part, on tobacco land. The tolerable soil loss ranges from 3 to 5 tons/acre/year. Animal populations in these counties are extremely small and should not be considered as a source of pollution.

Strip-cropping and grassed waterways are the most commonly used conservation practices. However, the number of acres treated is relatively small. A substantial increase is needed in the application of conservation practices to bring soil losses to within tolerable limits. The practices needed most are: diversions, sod waterways, and strip-cropping. Rotations, including hay, are needed for tobacco but may not be economically feasible.

Approximately 40 percent of the farms in this segment of the Patuxent have conservation plans. This low percentage is explained when an analysis is made of the definition of a farm. The Census of Agriculture defines a farm as any place from which 1,000 dollars or more of agricultural products was sold or normally would have been sold. This definition could include a farmer growing less than one half an acre of tobacco. Many farmers grow just a few acres, and they don't have conservation problems (i.e., are not district cooperators and do not seek conservation plans) Of the cooperators, 15 to 20 percent follow their plans completely while about the same number do not follow them at all. This leaves the majority of farmers implementing them in varying degress.

Approximately 30 percent of the cropland is leased. The leases are usually short-term so that farmers have little incentive to apply conservation to the land.

Trends in this segment are somewhat difficult to predict. Tobacco faces the same uncertainties of out-of-date markets and mechanization as described in the lower Potomac segments. Cash grain operations will increase in acreage and will rely heavily on leased land. Fertilizer and pesticide use will increase as the farmers convert to conservation tillage. The size of equipment will not increase substantially on the land farmed in tobacco but will on land farmed for cash grains.

## POTOMAC RIVER, NORTH BRANCH

Agriculture as a pollutor on this river basin segment is masked by the acid runoff from both active and abandoned coal mines. Also, agriculture is less intense here than anywhere else in Maryland.

The Soil Conservation Service is working to clean up pollution from the mines. The Rural Abandoned Mine Program (RAMP), administered by SCS and funded through the Department of Interior, is a program to reclaim existing abandoned mines and eliminate them from being a source of sediment and acid water. To date, three mines have been reclaimed with two more planned. Because the budget for the program is limited, only the surface of the problem is being scratched.

The active mining program falls under the Surface Mine Reclamation Act of the State of Maryland. This program adequately addresses sediment control and discharge of acid water during mining. Soil Conservation Districts review all plans for sediment control.

The cropping systems in this segment are not intense. Very little continuous corn is grown. Most commonly the rotation is one or two years of corn followed by a small grain and then followed by 3 to 5 years of hay. Tillage is for the most part by conventional means.

Although the rotations are not intense, the slopes are steep ranging from 5 to 25 percent resulting in soil losses averaging 5 to 6 tons/ac/yr. Tolerable soil losses are from 3 to 4 tons/ac/yr.

Most of the farmers in this segment are part-time operators with the majority of their income earned off the farm. Part-time farmers tend to expend little on lime and fertilizer which results in over-grazed pastures and low animal unit densities. Although the pastures are over-grazed, the soil losses, in most instances, fall within the tolerable limits.

Few dairy herds remain in this segment. The rugged topography limits crop production. Unable to expand to compete, those operations have either converted to less intensive beef operations or have reverted to woodland. Animal waste is not a problem because of the low animal density.

Conservation plans have been written on only a small portion of the farms in this segment. The plans, however, are on the active farms, the larger areas, and the farms having problems. The conservation problems are being addressed in this area. Statistics on conservation plans and plans implemented are misleading in this segment because many of the plans are for woodland or part-time operations.

Leased land varies widely by county ranging from about 5 percent in Garrett County to about 20 percent in Allegany County.

Conversion to conservation tillage will probably be slow in this segment. The farmers have a continuing need for conventional equipment for hay-land and pasture planting. Because the operations are small, the farmers cannot justify owning two sets of equipment. Even when low cost no-till pasture seeding equipment becomes available, the conversion will be slow.

Additional practices are needed on cropland to meet the tolerable limits of 3 tons/ac/yr. Practices such as strip-cropping, waterways, and diversions are needed. For pasture, the principal practices needed are: liming, fertilizing, rotational grazing, pasture management, and spring development. In woodland, timber stand improvement and sediment control during harvest are also needed.

The trends in this segment vary from state-wide trends in that there will not be an intensification of cropping systems. In this segment the equipment will not become larger; there is not a reliance on leased land,and conservation tillage will not become commonplace. The farms will continue as part-time farms with the owners earning a substantial portion of their income off the farm.

## POTOMAC RIVER – MAIN STEM FROM NORTH BRANCH TO LITTLE FALLS (INCLUDING MONOCACY)

This river segment drains one of the most intensively-farmed dairy regions of the state. Conservation programs are active on farms in these sub-watersheds with a substantial amount of conservation practices established. No-till and minimum till are practiced on the cropland and strip-cropping and waterways are commonplace. High priority has been established in the soil conservation districts to design and install all requests for assistance.

Noteworthy in this sub-watershed are two programs in addition to the traditional soil conservation program. The programs are aimed particularly at controlling sediment and animal waste runoff from agriculture.

First is the Rural Clean Water Project (RCWP) on Double Pipe Creek in Carroll County in the headwaters of the Monocacy basin. This joint USDA/EPA undertaking is an approximately 4 million dollar project and covers approximately 100,000 acres.

The second project is an SCS PL-566 Watershed Protection project on Seneca Creek in Montgomery County. Although not yet operational, the planning for this project is complete. The project will be implemented in conjunction with the construction of an emergency water supply reservoir on Little Seneca Creek by the Washington Suburban Sanitary Commission.

Approximately half of the cropland in this segment is in continuous corn with either no-till or minimum till being practiced. The residues are left on the land when corn is planted for grain while a cover crop is planted on the land when corn is produced for silage. Other cropping systems include rotations of two years of corn, followed by small grains and then 3 to 5 years of hay. In these systems, approximately 50 percent is planted by conventional-tillage methods and 50 percent is planted using some form of conservation tillage.

The average slope of most cropland is in the 3 to 8 percent range although a small percentage will be in the 8 to 15 percent range. The application of conservation tillage has reduced average annual soil loss to 5 to 7 tons/ac/yr. Additional practices needed to reduce soil loss down to the tolerable 3 tons/ac/yr are strip-cropping, diversions, waterways, and contour farming.

The high number and concentration of animals in this segment calls for special planning to control animal waste. Waste management systems plans are needed for most of the dairy operations. The plans address the proper handling of waste from its generation to its storage, and the application to the fields at rates to match crop needs. They also match timing of application to minimize the threat of runoff. The manure is not applied to frozen ground or in floodplains when the risk of flooding is high.

Estimates for the number of cattle in this segment vary from 150,000 to 200,000 with fairly even distribution throughout. The cost of installing the needed animal waste storage facilities varies, but best estimates are a mimimum of 6 million dollars.

Although there are constant pressures in this segment to convert active farmland to mini-farm and non-farm uses, the problems here are not of the same magnitude as in the Washington and Baltimore areas. In fact, the agricultural portion of Montgomery County is now in an exclusive agricultural zone utilizing transferable development rights. Also, more land has been purchased in Carroll County under the State Agricultural Preservation Program than in any other county in the state. This leads to a relative permanence of agriculture.

In this basin, approximately 60 percent of the farmers have conservation plans and the plans are more closely followed than in any other Maryland river basin. About 25 percent of the plans are followed in their entirety. However, about 10 to 15 percent are not followed at all. The plans in this segment are probably more current than any in the watershed because an active program of conservation planning has been followed in these counties for many years.

Although there is not a great amount of leased land (15 to 20 percent) in this segment, the problems associated with leased land exist. The situation here, however, is usually due to retired farmers leasing to other farmers rather than speculators or developers leasing to farmers. In this situation the lessor better understands the farmer's situation. Because of the short-term leases, however, the farmer does not have the incentive to apply conservation and his capital outlays are usually only for fertilizer and perhaps lime.

Trends in this segment will be a decrease in the number of dairy herds but with an increase in the herd size on those remaining. The number of cattle will remain constant. The farms will become more automated and cropping systems will intensify. More animal waste management systems will be installed and the efficient use of manure will be practiced. Some of the existing conservation practices will be removed to accomodate the larger equipment. Leasing of land will be more prevalent.

## POTOMAC RIVER – LITTLE FALLS AND SOUTH TO WOODBRIDGE

This river segment contains the urban and urbanizing Washington metropolitan area. These urbanizing activities are infringing on the agricultural lands. The farmers in this area are unable to compete for land with the developers and speculators and as a result cannot expand their operations as needed to keep economically viable units. The only way to be competitive is to rent from speculators on a short-term basis and to intensify their cropping systems.

The high percentage of the continuous cropland in this reach of the Potomac reflects the concerns above. Of the almost 1,100 farms, 70 percent of the cropland is in continuous corn and another 5 percent of the cropland is in continuous tobacco. Fortunately, the use of no-till or minimum tillage systems is widespread with much of the corn acreage in one of these tillage systems. For tobacco, however, the chemicals are not currently available for farmers to utilize this practice; therefore they plow, disc, and cultivate to produce the crop. The remaining 30 percent of cropland is planted to various rotations of corn, small grain and hay (25 percent), or soybeans for one or two years followed by 2 to 4 years of hay (5 percent). Minimum tillage is followed on much of this acreage the years it is cropped, but a seedbed is prepared in the years it goes to hay.

The average slope on the crop fields is from 4 to 15 percent; about equally divided in the slope categories 3 to 8 and 8 to 15 percent. Average soil losses are estimated to be 6 to 8 tons/ac/yr on all crops except tobacco which is estimated at 20 tons/ac/yr. The tolerable soil loss is 3 tons/ac/yr.

This segment has virtually no animals and therefore pollution from animal waste should not be considered.

The most typical conservation practices applied in this segment are conservation tillage, either no-till or minimum tillage, and sod waterways. To reduce soil loss to within tolerable limits, practices such as conservation tillage, strip-cropping, crop rotations, diversions, contouring, and sod waterways are also needed. High incentives will need to be offered to get conservation on the land in this segment because of the high cost of land and the impermanance of agriculture.

Approximately 40 percent of the farmers in this segment have conservation plans but most are not current. With the passage of the Maryland Sediment Control Law in 1970, the activities of SCS and SCD turned toward the urban programs. The agricultural program has suffered as a result because no new staff was provided. Of the farmers with conservation plans, only about 10 percent of them follow them completely. Seventy-five percent follow them to varying degrees. This is a reflection of out-of-date plans and a lack of an adequate follow-up system because of the lack of staff.

Leasing of agricultural land is commonly practiced in this segment. For the most part, land is leased for the short-term (1 yr) and at a high cost. This is true more so in this segment than any other segment in the basin. The situation of high rent and short-term is not conducive to applying conservation practices to the land. Few long-term conservation practices or practices which convert cropland to other uses are applied. Fortunately, conservation tillage is gaining widespread acceptance and is being applied on more and more of this land.

Needed practices in this segment are more conservation tillage, waterways, strip-cropping, diversions, contour farming, and crop rotations. Pasture management and animal waste management are not problems in this segment.

Future trends include continuing pressures on the use of land for agriculture. A decrease is expected in both the numbers of farms and the acreage of cropland. The future of the tobacco industry is uncertain due to new competition from other states and new mechanization in harvesting. Production of feed grains will remain but much of this will be on land leased from developers and speculators. The size of equipment will increase as will the amounts of fertilizer and herbicides applied.

## POTOMAC RIVER – WOODBRIDGE TO MOUTH – MARYLAND SIDE

Conversion from conventional to conservation tillage has not occurred in this segment of the river basin. The major obstacle to conversion is that many of the farmers are tobacco farmers and they need conventional equipment for growing that crop. They cannot justify owning two sets of equipment. This segment, plus the lower Patuxent, is the heart of the tobacco growing region in Maryland. Fifty percent of the tobacco grown in the State of Maryland is grown in the drainage area of this segment.

Cover crops are applied to virtually all tobacco land. The residues are left on corn and soybean ground. Approximately 25 percent of the cropland in this segment is in tobacco with 50 percent in corn and the remaining 25 percent in soybeans. There is little pastureland and waste management is not a problem.

Average slopes are in the 3 to 8 percent range, but cropping occurs on slopes up to 15 percent. Soil losses for corn and soybeans average 6 to 8 tons/ac/year, while on tobacco they are as high as 20 to 25 tons. The tolerable limits are 3 to 4 tons. There are over 2,400 farms in this segment, of which about 40 percent have conservation plans. Many of these plans are also out-of-date. Only 15 to 20 percent are followed in their entirety, and about the same percentage of plans are not followed at all.

Leasing of land is not as prevalent in this segment as it is in the upstream Metropolitan Washington area segment. Still, however, approximately 20 to 25 percent of the land is leased. Development pressures are strong in Charles County and those farmers face the same problems of high rent and short-term leases.

The need for conservation on cropland includes more conservation tillage on corn and soybean ground. Diversions, waterways, contour farming, strip-cropping, and longer rotations are also needed. The acreage in pasture and the number of animals in this segment are insignificant.

Pressures from development, especially in Charles County, will increase in this segment in the future. The same uncertainties of the tobacco industry are the same as in the segment to the north. The average size of a farm will not increase substantially, but the size of the cash grain operations will increase. The majority of land under cultivation will be leased. Conservation tillage will increase on all land, except where tobacco is grown, unless a break-through in technology occurs.

## SECTION 3

## CONTROL OPTIONS

Average annual soil losses throughout the Chesapeake Bay basin are in the range of 6 to 8 tons/ac/yr for most crops. Notable exceptions to this are tobacco and truck crops where the losses can range from 20 to 25 ton/ac/yr. The tolerable soil losses in the basin range from 1 to 5 ton/ac/yr with the vast majority of the soils in the 3 to 4 tons/ac/yr range.

Average reductions in soil loss of approximately 4 tons/ac/yr are needed on all crops except tobacco and truck crops. Currently, in Maryland, some form of conservation tillage is being practiced on about 60 percent of the cropland. Predictions are that by the year 2000, it will be practiced on 80 percent of all cropland and on 90 percent of the corn, small grain, and soybeans. In Pennsylvania, conservation tillage or no-till is presently practiced on about 45 percent of the cropland. It is predicted that by the year 2000, 60 percent of the cropland will be receiving no-till and conservation tillage. To qualify as conservation tillage, a minimum of 2,000 pounds per acre of crop residue needs to be maintained on the surface after planting. This increase will produce a net average reduction of 1 ton/ac/yr. Conservation tillage is not applicable to tobacco, vegetables, and truck crops because the chemicals are not yet available to control the weeds without injuring the crops.

Cost effectiveness of practices to reduce soil loss is difficult, if not impossible, to predict. Individual practices are planned and installed as part of cropping systems. The systems vary from the installation of one or two conservation practices to the installation of many practices. Systems vary from farm to farm and from field to field. Unlike tangible products, such as sewage treatment plants where greater treatment effectiveness translates into higher costs, in agricultural conservation systems, some of the least costly conservation practices can be the most effective. Conservation tillage is a prime example. It has low cost and the benefit is high.

Levels of treatment to meet a soil loss reduction can, however, be discussed in general terms. For example, if the present soil losses are 4 tons/ac/yr over the tolerable loss (T), or at T plus 4 level, then the losses can be reduced to T plus 2 and T. Generally speaking, they are categories of conservation practices that will accomplish each level of reduction.

As discussed, then T plus 3 level can be reached as farmers expand the use of conservation tillage, which, on the average, will reduce soil loss by 1 ton/ac/yr. The operating costs of conservation tillage are less than costs for conventional tillage, and by helping to maintain a productive soil base, conservation tillage is a benefit to the farmer. However, he does have to purchase new equipment. Some farmers will purchase this equipment ahead of their replacement schedule but many will delay purchase until the time when the old equipment wears out or becomes outdated.

Reductions below the T plus 3 level are generally costly. The cost to apply strip-cropping is high because this practice takes land out of crop production and puts it into hay, which does not always have a market. This practice is an option on some dairy farms but is not a viable option for most grain farms. Also, with rotations intensifying, use of this practice is expected to decrease.

Installation of filter strips is a practice gaining acceptance. This practice has no effect on changing soil loss, but it traps a percentage of the sediment before leaving the fields and prevents it from getting into the streams. The cost is the per acre cost of seeding and the cost of land lost from production.

Use of grassed waterways is another practice that does not reduce the calculated soil loss of a field. Waterways are either constructed or natural drainage-ways left out of cultivation and seeded to a close-growing grass. The purpose of a waterway is to carry stormwater safely off the field. It traps some sediments in the process when the grade is flat and the velocity is low. They are also constructed as outlets for diversions and terraces. Costs vary from a per acre seeding cost for natural waterways to a cost for construction of the waterway plus the seeding cost. Land is also lost from production.

Contour farming is a practice that does reduce soil loss. True contouring is becoming less popular as the size of equipment becomes larger. Cross slope farming is used when true contouring is impractical. All of the above, except contouring and cross-slope farming, have a cost of land taken from cropping.

To reach the tolerable soil loss (T) requires a unique combination of a number of the above practices in addition to practices such as diversions and terraces. Diversions take land out of production and terraces, although they do not take land out of production, are suited to only a limited number of acres. With the advent of larger equipment, it is important to have these as parallel as possible, but to do this the land has to slope uniformly. Cut and fill terraces are installed in Pennsylvania to maintain uniform spacing and alignment. Although this technique increases the cost, it will make the terrace system more useable and practical for farmers. The costs for diversions are the costs of construction, the seeding costs, and the cost of land removed from cropping. The costs of terraces are related primarily to the costs of construction.

Another method of control is not to be concerned as much with meeting the T level as it is concerned with preventing the sediments from entering the water. This is sediment control versus erosion control, and does not protect the agricultural land base. It must be recognized that when sediment control is undertaken, there are no benefits accrued to the farmer. The benefits are to the downstream water-user. Farmers often suggest that because the benefits are to the public, the costs should be borne by the public. A combination of sediment control and erosion control is probably needed on lands where erosion rates are high, such as on tobacco and truck cropland, as well as on fragile cropland in grain.

Sediment control practices include sediment basins, sediment traps, and filter strips. The basins and traps are expensive to install and have high operation and maintenance costs. Inspection is required to ensure that the basins are cleaned out to operate at their designed trap efficiency.

Animal waste management systems are needed on an estimated 50 to 60 percent of the livestock, hog, and poultry operations in the basin. Systems can be simply the planning or the timing of manure application to minimize its runoff and the planning of application rates to meet the crop needs. In many instances, however, more complex systems are needed. These can consist of storage facilities, traps, lagoons, pumps, pipes, and special handling equipment. Costs of these systems can vary from 15,000 to 100,000 dollars and more.

In Maryland, the State Soil Conservation Committee (SSCC) estimated the cost of adequately carrying out the present agricultural and urban sediment control programs and to implement the 208 program. Estimates for technical assistance alone amounted to over 1 million dollars per year. Implementing best management practices in the top three priority areas would cost 24 million dollars over a 10 year period. An estimated 11.6 million dollars in Federal cost-sharing funds will be available over the next 10 years in current Federal programs that provide assistance in the application of practices that relate to water quality. These funds require matching local funds ranging from 25 to 40 percent. The matching required funds are estimated from between 3 to 8 million dollars. This indicates a shortage of 3.6 to 7.6 million dollars over the next 10 years. The new State of Maryland 10 million dollar agricultural cost-share program should help to alleviate conservation needs in at least the top three critical areas.

Soil conservation districts will concentrate available resources in the critical areas. However, the amount of assistance currently obtainable, both cost-sharing and technical, is not sufficient to meet all the goals of the Maryland Agricultural Water Quality Program.

SECTION 4

# ADMINISTRATIVE ALTERNATIVES

## INTRODUCTION

Congress, in its concern about the condition of the nation's basic non-federal resources, passed the Soil and Water Resources Conservation Act of 1977 (RCA). In the Act, Congress asked the Secretary of Agriculture three basic questions:

1. What are the resource problems?
2. How do you propose to solve these problems?
3. What are the expected results of your solution?

### The Problem

The Secretary conducted an appraisal to determine the status, condition, and trends of the nation's soil, water, and related resources. The 1980 RCA Appraisal showed that conservation problems threaten to reduce agricultural productive capacity and increase production costs. Specific findings of the Appraisal include:

- Much agricultural land is eroding faster than the soil can rebuild itself through natural processes. Unless corrective actions are taken, the acreage of this excessively eroding land will increase further.
- Floods threaten human life, property, livestock, and crops in upstream watersheds. The likelihood is for greater damage in the future.
- Depletion of ground water threatens the continuation of irrigated agriculture in extensive areas of the west, and isolated areas in the east, such as the orchard areas in south-central Pennsylvania.
- Deterioration of water quality limits potential use of water for irrigation, municipal and industrial supply, fish and wildlife habitat, and other purposes.

### Alternative Strategies

To accomplish the objectives proposed for each resource area, alternative approaches for carrying out the activities have been examined. Any of these strategies or a combination of them could be used in future programs. Some could be tested in a specific area for a period of time to determine their effectiveness. Regional and state differences in governmental administration, laws, tax structures, land-use controls, and social and economic structure will effect a given conservation strategy.

A key test of the alternative strategies is whether or not they effectively achieve conservation objectives. The full range of strategies runs from no Federal action to complete regulation. The strategies presented below are thought to be consistent with the intent of the RCA and are offered for consideration and comment.

Natural resource problems tend to be caused by the failure of established institutions to reflect the full social value of soil and water resources to those who use them. Commodity markets offer financial rewards to farmers for the production of crops and livestock. The dependence of farmers on those markets for income tends to force them to maximize the production of marketable commodities over the near-term. Expenditures for the conservation of soil and water resources in general produce few near-term benefits, if any. Therefore, the market offers no near-term rewards to farmers for the conservation of soil and water resources. Consequently, farmers tend to emphasize near-term production for current income at the expense of the social value of natural resources.

Before and during the Great Depression, few substitutes for natural fertility were available. Consequently, farmers practiced conservation to prevent yield reductions. Over the past 40 years, commercial fertilizers, pesticides, new plant varieties, and the intensive use of multi-row equipment have tended to reduce farmer's near-term motivation to practice soil and water conservation. Increases in land prices and in the variable costs of production have tended to reduce net income margins on a per acre basis. This requires relatively more land to maintain a given level of net farm income. Widespread leasing of farmland, speculation in land, and other changes in land tenure suggest that reliance on a close family attachment to land as a motivation to conserve may not be appropriate or effective. Between 2 and 3 percent of all agricultural land changes ownership annually. Over half of all agricultural land has changed ownership since 1960.

In summary, farming today is a business requiring the investment of time and money resources to achieve maximum return on that investment. The incentive to conserve must fit into the plan of investing in resources and reaping benefits.

Given the issues above which tend to limit the extent of conservation, seven strategies were presented for organizing and delivering conservation programs at the national level: redirecting present programs, cross compliance among USDA programs, regional resource projects, State leadership, regulatory emphasis, conservation performance bonus, and natural resource contracts. Farmers, conservation districts, and farm organizations viewed these strategies with varying degrees of acceptance ranging from a totally non-acceptable regulatory program to the preferred voluntary program with increased incentives. From these seven strategies, the USDA put together a preferred program, Alternative 1 -- continuation of current program trends and alternative 2 -- redirection of Federal programs.

USDA Preferred Programs--

Based upon the responses to the seven strategies, the USDA developed a preferred program that establishes clear national priorities for addressing problems associated with soil, water, and related resources over the next five years. The highest priority of the preferred program is reduction of soil erosion to maintain the long-term productivity of agricultural land. The next highest priority is reduction of flood damages where risks are highest in upstream areas. Water conservation and supply management, water quality improvement, and community-related conservation problems have next priority. Fish and wildlife habitat improvement and organic waste management are an integral part of solutions to these problems.

This program strengthens the existing partnership among land-owners and users, local and state governments, and the Federal government. Through this partnership the program:

- Provides Federal matching block grants to states by reducing Federal conservation program funds.
- Provides for a Local Conservation Coordination Board made up of representatives of the conservation district, county Agriculture Stabilization and Conservation (ASC) committee, extension advisory committee, and other interested parties. This board will appraise local conditions and needs and develop a program through existing local, state, and Federal institutions. The local board will identify critical resource problem areas and set priorities for action to achieve program objectives.
- Provides for a State Conservation Coordinating Board, with members appointed by the Governor, to appraise overall state resource conditions and needs. This board will build on local programs in identifying state-wide critical problem areas, setting priorities, and developing the state program.
- Establishes a USDA National Conservation Board to advise the Secretary of Agriculture on conservation matters.
- Bases state and Federal cooperative conservation actions on an agreement between each Governor and the Secretary of Agriculture.

Continues or initiates actions to:

- Target an increased proportion of USDA conservation program funds and personnel to critical areas where soil erosion or other resource problems threaten the productive capacity of soil and water resources.
- Emphasize conservation tillage and other cost-efficient measures for reducing soil erosion and solving related problems.
- Evaluate tax incentives as an inducement to increased use of conservation systems.
- Increase emphasis on technical and financial assistance to farmers and ranchers who plan and install any needed cost-efficient conservation system.
- Target USDA research, education, and information services toward problems that impair agricultural productivity, while continuing basic research into the causes and cures of resource degradation.
- Set up pilot projects to test new solutions to conservation problems.
- Require land-owners to have a conservation plan in order to be eligible for Farmers Home Administration loans (cross-compliance).

- Minimize conflicts among features of USDA farm programs that limit achievement of conservation objectives.
- Strengthen collection and analysis of resource data.
- Evaluate and analyze conservation progress.
- Expand the use of long-term agreements in providing conservation assistance to farmers or ranchers.

Alternative 1 -- Continuation of Current Program Trends--

Current trends in the USDA soil and water conservation programs would continue with this alternative. These trends, if continued, would result in lower funding and further degradation of soil, water, and related resources.

Alternative 2 -- Redirection of Federal Programs--

The USDA would redirect its programs with this alternative so that it would target a larger share of its assistance to solving critical resource problems. Resource conditions would at best improve only slightly from what they are now.

## Conclusions

The Secretary rejected these alternatives as too weak to solve the problems and unresponsive to public opinion.

Of the preferred program and the two alternative programs presented, Maryland respondents showed most support for the Secretary's preferred program, with changes. About 71 percent supported the preferred program compared to 36 percent for Alternative 1 (Continuation of Current Trends) and 24 percent for Alternative 2 (Redirection).

Comments show respondents did not like all aspects of the preferred program. They opposed block grants (unless accompanied by additional funding) and the creation of new local, state, and national coordinating boards. They were divided on the issues of targeting and having local boards identify and solve critical problems. An overwhelming majority of respondents felt that Federal funding for conservation should be increased over that called for in the program alternatives. They felt that erosion would increase and the resource base degrade if Federal conservation assistance was reduced in Maryland.

Those who supported Alternative 1 thought current programs were effective and should be improved through increased funding and the legislative process. Comments on Alternative 2 varied considerably from support to opposition.

In Pennsylvania--

Alternative 1, Continuation of Current Program Trends, was supported by 60.3 percent of those individuals responding on the response form. In addition, 173 narrative comments were processed and indicated, by an 88.4

percent margin, support for the continuation of current programs. This support was further qualified by 47 commenters favoring continuing present programs with additional money, and 75 voting continuation with no qualifying factors. A small number favored continuation but suggested that program refinement was needed.

The preferred program was opposed by a majority of respondents. Approximately one-third of the respondents, 729 persons, supported this alternative with 28 qualifying their support with the formation of no new committees and grants being funded from new or additional monies. Narrative commenters were critical of this alternative, citing the unnecessary formulation of new boards, duplication of services, and a discriminatory posture the alternative takes toward the northeast. There is a general opinion that the soil loss criteria for targeting does not adequately address or consider the fragile soils of the northeast and would have detrimental impacts on this region. There was also concern that states could not handle program responsibilities as well as the Federal government.

Alternative 2, Redirection of Federal Programs, was opposed by 52.7 percent of the respondents. There were 31 percent supportive of this alternative and 16.4 percent were neutral. In evaluating this alternative, there were very few comments and no clear indication of why or how respondents took the position they selected.

The National Association of Conservation Districts, representing conservation districts nation-wide, supported the preferred program with reservations. Their opinion is that state associations, state conservation committees, and local Soil Conservation Districts are already in place and no new committees are needed. If block grants are given, it should be funneled through these groups. They also feel the grants should be from new money.

## RECOMMENDATIONS FROM MARYLAND AND PENNSYLVANIA

Presently the USDA's Agricultural Stabilization and Conservation Service (ASCS) has cost-share programs to share costs on the installation of conservation practices. This program has limited funds authorized by Congress and has a 3,500 dollars limitation on payment to any farmer each year. This limitation has been in effect for a number of years. The cost of installing the practices has risen dramatically over these years. Although the program can theoretically pay up to 75 percent of the cost, the 3,500 dollar maximum prevents this from happening. This is especially true for animal waste management systems where the costs range from 15,000 dollars to over 100,000 dollars per system. Annually, members of Congress have tried to get this limitation removed as well as trying to get the total appropriation increased. These efforts have been unsuccessful. At best, the program has maintained a constant level from year to year. Renewed efforts are needed at the national level to increase the minimum cost-share payments.

## State Cost-Share Program

The 1982 session of the Maryland General Assembly passed a state cost-share bill authorizing expenditures of 500,000 dollars per year for a 10-year period for the installation of the best management practices. The program is supplemental to the Federal ASCS program. It would authorize up to 87 percent of the cost of establishing eligible practices not to exceed 5,000 dollars per operating unit per year. This cost-sharing program would be implemented at the soil conservation district level. Pennsylvania does not have a state cost-share program.

## OTHER PROGRAMS

The Maryland State Soil Conservation Committee and the Pennsylvania State Conservation Commission, representing soil conservation districts and state agricultural leaders, support the following programs:

### Tax Incentives

To investigate methods for financial assistance such as low interest loans and tax incentives for the installation of conservation practices. It is felt that low-cost money would stimulate the application of conservation practices.

### Agricultural Land Preservation

To actively promote and support State Agricultural Preservation Programs. Farmers in Maryland have been active in forming agricultural districts, but more money is needed for the state to purchase development rights on agricultural land.

### Technical Assistance

To provide assistance necessary for districts to develop a farm-conservation plan on each farm in the two states. This assistance will require substantial increases in funding to conservation districts. Sources of this funding are not identified at present.

### Drainage -- Maryland

To advocate increased cost-sharing for maintenance of ditches as allowed under Section 8 of the Agricultural Code of Maryland. Improved drainage allows farmers to change from a rotation of continuous soybeans to a corn/soybean rotation or a double-cropped corn/small grain/soybean rotation. Both reduce soil losses.

Other alternative strategies that may be considered are:

### Conservation Planning

Conservation plans could be required on all agricultural land in the basin. The plans could be written by the farmer, an agricultural consultant, the SCS, or the SCD. The plans would need to be approved by the SCD. Once approved, additional technical help would be needed for application of the practices.

## Leased Land

Lack of conservation on leased land is of major concern in the basin. One potential solution is to disallow agricultural preferential taxes unless the land has sound conservation practices and allowable soil loss limits are being achieved. Care has to be exercised that the owner, rather than the user, pays the costs of applying the conservation.

## Regulatory Program

A regulatory program for agriculture has generally been discarded as an ineffective means to accomplish the objective. It is felt that with adequate staffs and appropriate cost-sharing, conservation could be applied to 90 to 95 percent of the land. Should a regulatory program be established, it is felt that an advisory relationship would be established between the farmer and the agricultural agencies. In addition, it is also felt that large sums of money would be required to hire inspectors for enforcement. Agricultural leaders are convinced that this money would be more wisely invested in cost-share programs.

# SECTION 5
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# ATTACHMENT 1

## MARYLAND
## USDA 1982 Resources Conservation Act
## Executive Summary - Maryland and Washington, DC

This report is based on 1,271 responses received in the state of Maryland during the November 1981-January 1982 RCA public response period. These were responses to the Secretary of Agriculture's Preferred Program for conserving the Nation's soil and water resources. The Program is described in the USDA publication, "1981 Program Report and Environmental Impact Statement, Revised Draft".

Analysis of the responses show that the majority of respondents, 73 percent, are affiliated with a group that has a stake in the final program. About 27 percent were agricultural organization members, 15 percent, local or state government employees or officials; 9 percent, USDA employees or officials; 9 percent, environmental organization members; 6 percent, conservation district board members; 5 percent, county ASC committee members; 2 percent, federal employees or officials other than USDA; and 26 percent, individuals. About 53 percent were farmers.

Of the three alternative programs presented, respondents showed most support for the Secretary's preferred prgram, with changes. About 71 percent supported the preferred program compared to 36 percent for Alternative 1 (Continuation of Current Trends) and 24 percent for Alternative 2 (Redirection).

Comments show respondents did not like all aspects of the preferred program. They opposed block grants (unless accompanied by additional funding) and the creation of new local, state, and national coordinating boards. They were divided on the issues of targeting and having local boards identify and solve critical problems. An overwhelming majority of respondents felt federal funding for conservation should be increased over that called for in the program alternatives. They felt that erosion would increase and the resource base degrade if federal conservation assistance was reduced in Maryland.

Those who supported Alternative 1 thought current programs were effective and should be improved through increased funding and the legislative process. Comments on Alternative 2 varied considerably from support to opposition. Reaction to each of the preferred program features follows:

Feature 1 -- A strong majority favored setting clear national priorities. The majority agreed that erosion and flood control should be national priorities. Some felt national priorities should be balanced with local needs and suggested other resource problems be considered high priority as well.

Feature 2 -- There was strong support for strengthening existing partnerships among landowners and users, local, and state governments, and the Federal government.

Feature 3 -- The majority of respondents opposed block grants. Comments show they favored the concept, but objected to funding grants by reducing current conservation programs.

Feature 4 -- Respondents rejected the idea of creating local coordinating boards. They felt existing local conservation districts should assume this function.

Feature 5 -- Although a small majority supported having local boards identify and set priorities for critical resource problem areas, comments show respondents felt conservation districts should have this function since they were already doing this.

Feature 6 -- Respondents opposed the creation of a new state conservation coordinating board. They felt this should be handled by the existing State Soil Conservation Committee.

Feature 7 -- Respondents opposed creating a national coordinating board. They felt the role of this board had not been clearly defined.

Feature 8 -- A majority favored cooperative agreements between the Governor and the Secretary of Agriculture.

Feature 9 -- Respondents endorsed the idea of closer cooperation and budget coordination among USDA agencies.

Feature 10-- Respondents were divided on the issue of targeting funds and personnel to critical problem areas. Comments show they felt targeting should be done with additional funding.

Feature 11-- Respondents supported emphasizing cost-effective conservation measures.

Feature 12-- Using tax incentives as inducements for practicing conservation received strong support.

Feature 13-- Respondents strongly supported USDA emphasizing assistance for planning and installing conservation systems.

Feature 14-- Targeting research and education toward conservation problems that impair productivity received strong support. Those who commented thought information and education programs should be improved and funded.

Feature 15-- Respondents supported the idea of pilot projects.

Feature 16-- A slim majority supported the idea of cross compliance for FmHA borrowers. Those who commented felt plans should be implemented and be required for all USDA programs.

Feature 17-- Respondents favored evaluating and analyzing conservation progress.

Feature 18-- A large majority supported minimizing conflicts among USDA farm programs.

Feature 19-- Respondents supported strengthening data collection and analysis.

Feature 20-- Respondents supported expanding the use of long-term agreements.

All 39 responding districts opposed this feature as a duplication of the State Conservation Commission as established under Pennsylvania law. All farm organizations opposed while government was divided, four in favor and seven opposed.

Opposed were 73.3 percent of the individual respondents, citing similar reasons as conservation districts.

7. Establishing a USDA national conservation board which advises the Secretary of Agriculture.

State and local governments, including conservation districts, expressed heavy opposition to this feature as too political, bureaucratic, and lacking purpose.

Individuals opposed this feature by 58.5 percent for the same reasons as presented by governmental units.

8. Basing cooperative actions on an agreement between each Governor and the Secretary of Agriculture.

Approximately one-fourth of those responding, both groups and individuals, were neutral on this issue. The USDA-Governor agreement is weakly opposed without a majority for or against this feature.

9. Providing closer cooperation and budget coordination among USDA agencies with conservation program responsibilities.

All groups and individuals heavily supported this feature.

10. Targeting more USDA funds and personnel to areas where erosion or other conditions threaten the productive capacity of soil and water resources.

All groups and individuals supported this feature to varying degrees. A general concern was voiced that targeting could be discriminatory against Pennsylvania and the Northeast. The criteria for targeting does not give consideration to the fragile soils of the Northeast and other factors like nearness to markets and population.

11. Emphasizing the conservation measures that are most cost-effective in reducing erosion.

All groups and individuals heavily supported this feature. They did cite a need for management systems, future study of effects and additional financial incentives.

12. Evaluating tax incentives as an inducement to increase use of conservation systems.

All groups and individuals heavily endorsed tax incentives as encouraging soil and water conservation application.

Respondents also volunteered comments on other resource topics not specifically covered in the program alternatives. Significant numbers of respondents felt that water management (drainage), preservation of prime farmland, urban conservation, and water quality should receive consideration in USDA programs.

Respondents who commented on the RCA process felt that the questionnaire was biased and was constructed to elicit the comments USDA wanted. Others felt the documents were also biased and did not present enough objective information.

Many of the comments volunteered by respondents concerned funding of programs. Most felt that conservation programs were not adequately funded and that funding should be increased.

## ATTACHMENT 2

### PENNSYLVANIA
### USDA 1982 Resources Conservation Act
### Executive Summary - Pennsylvania and Washington, DC

This report is based on 2,291 individual and 71 group and governmental unit responses received in Pennsylvania during the November 1981-January 1982 RCA public response period. These were responses to the Secretary of Agriculture's preferred program for conserving the Nation's soil and water resources. The program is described in the USDA publication, "1981 Program Report and Environmental Impact Statement, Revised Draft".

The Preferred Program, was opposed by a majority of respondents. Approximately one-third of the respondents, 729 persons, supported this alternative with 28 qualifying their support with the formation of no new committees and grants being funded from new or additional monies. Narrative commenters were critical of this alternative, citing the unnecessary formulation of new boards, duplicatio of services, and a discriminatory posture the alternative takes toward the Northeast. There was also concern that states could not handle program responsibilities as well as the Federal government.

There is general opinion that the soil loss criteria for targeting does not adequately address or consider the fragile soils of the Northeast and would have detrimental impacts on this region.

Alternative 1, Continuation of Current Program Trends, was supported by 60.3 percent of those individuals responding on the response form. In addition, 173 narrative comments were processed and indicated by an 88.4 percent margin to support continuation of current programs. This support was further qualified by 47 commenters favoring continuing present programs with additional money, and 75 voting continuation with no qualifying factors. A small number favored continuation but suggested program refinement was needed.

Alternative 2, Redirection of Federal Programs, was opposed by 52.7 percent of the respondents. There were 31 percent supportive of this alternative and 16.4 percent were neutral. In evaluating this alternative, there were very few comments and no clear indication of why or how respondents took the position they selected.

### FEATURES OF PREFERRED PROGRAM

1. Establishing clear national priorities for addressing conservation problems.

Of 2,130 individual responses, 80.1 percent supported the establishment of national priorities. Twenty-eight of 31 conservation districts backed this feature. State and local governments supported this concept by a nine to one response.

TABLE 2.1 PUBLIC RESPONSE TO ALTERNATIVES (Pennsylvania 1981-1982)

| Alternative | Strongly Support | Support | Neutral | Oppose | Strongly Oppose | Opinion |
|---|---|---|---|---|---|---|
| Preferred Program--Redirection Plus Expanded Roles for Local and State Governments | 237_/ | 492 | 145 | 291 | 833 | 293 |
| | 11.9 | 24.6 | 7.3 | 14.6 | 41.7 | |
| Alternative 1--Continuation of Current Program Trends | 687 | 521 | 261 | 381 | 154 | 287 |
| | 34.3 | 26.0 | 13.0 | 19.0 | 7.7 | |
| Alternative 2--Redirection of Federal Program | 178 | 385 | 298 | 503 | 456 | 471 |
| | 9.8 | 21.2 | 16.4 | 27.6 | 25.1 | |

1/ Top line - number; second line - percentage

2. Strengthening the existing partnership among landowners and users, local and State governments, and the Federal government.

Thirty-seven of 41 State and local governments, including conservation districts, supported strengthening the existing partnership. Of 2,120 individual responses, 69 percent supported this feature. Of 63 written comments, 84 percent felt control of soil and water conservation programs should be at the local level. Sixteen of 28 comments on conservation districts stated that districts did involve the public, set priorities and identify problem areas.

3. Providing Federal matching block grants to states by reducing Federal conservation program funds.

Overall response by individuals opposed block grants by 78.7 percent. Thirty-two of 40 conservation districts opposed block grants, but 27 opposed unless there was new money for grants. Five of six farm organizations and five units of State and local governments took a similar position. Three farm organizations and five units of government felt that Pennsylvania could not afford its share of the matching block grants.

4. Providing for a local conservation coordinating board, make up of representatives of the conservation district, county ASC committee, Extension Advisory committee, and other interested parties.

The 39 responding conservation districts and all responding farm organizations were unanimous in their opposition to local conservation coordinating committees. Local and State governments were evenly split in support and opposition. Of 2,147 individuals replying, 63.9 percent opposed. Written comments from groups and individuals indicated this responsibility is being done by conservation districts as stipulated by Pennsylvania law and would increase bureaucracy and red tape.

5. Having the local board identify critical resource problem areas, set priorities for action, and develop the local conservation program.

Opposing this feature were 53.6 percent of the individual responses. Of 65 written comments, 37 expressed the opinion that this was already accomplished by conservation districts and/or ASC committees.

6. Providing for a State conservation coordinating board, appointed by the Governor, that identifies State critical problem areas, sets priorities, and develops the State conservation program.

All 39 responding districts opposed this feature as a duplication of the State Conservation Commission as established under Pennsylvania law. All farm organizations opposed while government was divided, four in favor and seven opposed.

Opposed were 73.3 percent of the individual respondents, citing similar reasons as conservation districts.

7. Establishing a USDA national conservation board which advises the Secretary of Agriculture.

State and local governments, including conservation districts, expressed heavy opposition to this feature as too political, bureaucratic, and lacking purpose.

Individuals opposed this feature by 58.5 percent for the same reasons as presented by governmental units.

8. Basing cooperative actions on an agreement between each Governor and the Secretary of Agriculture.

Approximately on-fourth of those responding, both groups and individuals, were neutral on this issue. The USDA-Governor agreement is weakly opposed without a majority for or against this feature.

9. Providing closer cooperation and budget coordination among USDA agencies with conservation program responsibilities.

All groups and individuals heavily supported this feature.

10. Targeting more USDA funds and personnel to areas where erosion or other conditions threaten the productive capacity of soil and water resources.

All groups and individuals supported this feature to varying degrees. A general concern was voiced that targeting could be discriminatory against Pennsylvania and the Northeast. The criteria for targeting does not give consideration to the fragile soils of the Northeast and other factors like nearness to markets and population.

11. Emphasizing the conservation measures that are more cost-efficient in reducing erosion.

All groups and individuals heavily supported this feature. They did cite a need for management systems, future study of effects and additional financial incentives.

12. Evaluating tax incentives as an inducement to increase use of conservation systems.

All groups and individuals heavily endorsed tax incentives as encouraging soil and water conservation application.

13. Emphasizing USDA assistance to farmers and ranchers for planning and installing conservation systems.

All State organizations, including districts, strongly prefer this feature. Individuals provided 86.1 percent support for planning and installing conservation systems.

14. Targeting USDA research and education services toward conservation problems that impair agricultural productivity.

All groups and individuals provided heavy support to this feature.

15. Setting up pilot projects to test new conservation methods.

Individuals supported by 72.8 percent while state-wide groups gave this feature 81.8 percent endorsement.

16. Requiring landowners to have a conservation plan in order to be eligible for Farmers Home Administration loans.

The 2,000 plus individuals responded with 59.3 percent support. Conservation districts and State and local governments supported by 88.8 and 70 percent, respectively. The feature was opposed by agricultural organizations and academic institutions. Comments included: (1) conservation plans must be implemented; (2) expand to all USDA conservation programs; (3) conservation programs remain voluntary; (4) not uniform in effects on types of agricultural operations; and (5) places unfair financial hardship on young persons getting started in agriculture.

17. Evaluating and analyzing conservation progress.

This feature has strong support from all groups and individuals (75.7 percent), but contains no clear direction for implementing.

18. Minimizing conflicts among features of USDA farm program that limit achievement of conservation objectives.

Individuals supported by 78.4 percent. Conservation districts endorsed 28 to one and other state-wide groups provided a 43 to one support margin.

19. Stengthening data collection and analysis for identifying conservation problems.

All individuals and groups provided support for this feature. Those actively engaged in farming provided a lesser degree of support and indicated a desire that funds be spent to assist in conservation practice application rather than in studies.

20. Expanding the use of long-term agreements between USDA and farmers and ranchers.

Although all groups supported, this feature has a heavy neutral vote. Over 50 percent of the responding districts were neutral (15), the remaining districts did support the feature 12 to 1. Almost one-fourth of the individuals were neutral on long-term agreements as were 37.5 percent of state-wide groups.

TABLE 2.2 FEATURES OF PREFERRED PROGRAM, PENNSYLVANIA 1981 - 1982

| Features of Preferred Program Pennsylvania 1981 - 1982 | Strongly Support | Support | Neutral | Oppose | Strongly Opposed | Opinion |
|---|---|---|---|---|---|---|
| 1. Establishing clear national priorities for addressing conservation problems. | 1,130<br>53.0 | 577<br>27.1 | 125<br>5.9 | 132<br>6.2 | 167<br>7.8 | 160 |
| 2. Strengthening the existing partnership among land owners and users, local and State governments, and the Federal government. | 794<br>37.5 | 670<br>31.6 | 334<br>15.8 | 135<br>6.4 | 187<br>8.8 | 171 |
| 3. Providing Federal matching block grants to states by reducing Federal conservation program funds. | 97<br>4.6 | 157<br>7.4 | 199<br>9.3 | 371<br>17.4 | 1,306<br>61.3 | 161 |
| 4. Providing for a local conservation coordinating board, made up of representatives of the conservation district, county ASC committee, Extension Advisory committee, and other interested parties. | 304<br>14.2 | 370<br>17.2 | 101<br>4.7 | 249<br>11.6 | 1,123<br>52.3 | 144 |
| 5. Having the local board identify critical resource problem areas, set priorities for action, and develop the local conservation program. | 469<br>22.0 | 396<br>18.6 | 126<br>5.9 | 270<br>12.7 | 873<br>40.9 | 157 |
| 6. Providing for a State conservation coordinating board, appointed by the Governor, that identifies State critical problem areas, sets priorities, and develops the State conservation program. | 127<br>6.0 | 262<br>12.3 | 180<br>8.4 | 419<br>19.7 | 1,143<br>53.6 | 160 |
| 7. Establishing a USDA national conservation board which advises the Secretary of Agriculture. | 152<br>7.2 | 335<br>15.9 | 389<br>18.4 | 362<br>17.1 | 874<br>41.4 | 179 |

(continued)

TABLE 2.2

| Features of Preferred Program Pennsylvania 1981 - 1982 | Strongly Support | Support | Neutral | Oppose | Strongly Opposed | Opinion |
|---|---|---|---|---|---|---|
| 8. Basing cooperative actions on an agreement between each Governor and the Secretary of Agriculture. | 292<br>14.0 | 438<br>21.0 | 483<br>23.1 | 328<br>15.7 | 548<br>26.2 | 202 |
| 9. Providing closer cooperation and budget coordination among USDA agencies with conservation program responsibilities. | 813<br>38.3 | 908<br>42.8 | 185<br>8.7 | 75<br>3.5 | 142<br>6.7 | 168 |
| 10. Targeting more USDA funds and personnel to areas where erosion or other conditions threaten the productive capacity of soil and water resources. | 549<br>25.7 | 765<br>35.8 | 158<br>7.4 | 273<br>12.8 | 390<br>18.3 | 156 |
| 11. Emphasizing the conservation measures that are most cost-effecient in reducing erosion. | 921<br>43.3 | 918<br>43.2 | 108<br>5.1 | 54<br>2.5 | 126<br>5.9 | 164 |
| 12. Evaluating tax incentives as and inducement to increased use of conservation systems. | 1,011<br>47.8 | 715<br>33.8 | 158<br>7.5 | 86<br>4.1 | 144<br>6.8 | 221 |
| 13. Emphasizing USDA assistance to farmers and ranchers for planning and installing conservation systems. | 1,090<br>51.4 | 736<br>34.7 | 115<br>5.4 | 53<br>2.5 | 125<br>5.9 | 218 |
| 14. Targeting USDA research and education services toward conservation problems that impair agricultural productivity. | 858<br>40.7 | 820<br>38.9 | 194<br>9.2 | 95<br>4.5 | 140<br>6.6 | 184 |
| 15. Setting up pilot projects to test new conservation methods. | 767<br>36.2 | 776<br>36.6 | 293<br>13.8 | 125<br>5.9 | 157<br>7.4 | 221 |
| 16. Reducing landowners to have a conservation plan in order to be eligible for Farmers Home Administration loans. | 736<br>34.4 | 532<br>24.9 | 397<br>18.9 | 219<br>10.2 | 256<br>12.0 | 191 |

(continued)

TABLE 2.2

| Features of Preferred Program Pennsylvania 1981 - 1982 | Strongly Support | Support | Neutral | Oppose | Strongly Opposed | Opinio |
|---|---|---|---|---|---|---|
| 17. Evaluating and analyzing conservation progress. | 670<br>32.0 | 915<br>43.7 | 283<br>13.5 | 88<br>4.2 | 139<br>6.6 | 253 |
| 18. Minimizing conflicts among features of USDA farm program that limit achievement of conservation objectives. | 759 | 894 | 273 | 59 | 123 | 237 |
| 19. Strengthening data collection and analysis for identifying conservation problems. | 640<br>30.3 | 796<br>37.7 | 343<br>16.3 | 162<br>7.7 | 169<br>8.0 | 181 |
| 20. Expanding the use of long-term agreements between USDA and farmers or ranchers. | 487<br>22.9 | 659<br>31.0 | 506<br>23.8 | 190<br>8.9 | 281<br>13.2 | 210 |

Top line - numbers; bottom line - percentage

## STATE SOIL CONSERVATION PRACTICES ACT

The State of Pennsylvania does not have a financial or cost-share program to aid in the application of soil and water conservation practices.

The State does provide financial assistance to conservation districts in employment of personnel, acquisition of landrights under Public Law 566, the Watershed Protection and Flood Prevention Act, and has in the past, financially supported the soil survey program.

RCA grant monies in 1979-1980 were used by the State Conservation Commission to prepare a State Conservation Plan, "Directions for the 80's". These funds were also provided to 10 conservation districts to update long-range programs and another 11 districts to make special resource studies.

## CONSERVATION ETHIC AND ATTITUDES

Responses implied that conservation of soil should be as high a national priority as defense. Another thought was that conservation plans were invaluable, but to achieve full value, needed to be implemented on the land.

There was also a concern over the credibility of USDA since the preferred program and other alternatives did not reflect earlier public inputs into RCA and may have influenced the number of responses during this response period.

## CURRENT USDA CONSERVATION ACTIVITIES

In fiscal year 1981, SCS provided soil and water conservation assistance to 24,400 land users and 1,229 units of government, in cooperation with conservation districts. Assistance was provided through programs such as Resource Conservation and Development (RC&D), Rural Abandoned Mine Program (RAMP), Agricultural Conservation Program (ACP), Soil Survey, River Basins, Watershed Protection and Flood Prevention, Rural Clean Water Program, Emergency Watershed Protection, Inventory and Monitoring, education and information, and Conservation Operations (assistance to conservation districts).

## SUMMARY OF PUBLIC RESPONSES

A total of 2,291 individuals provides comments on the Secretary's preferred program and other alternatives.

In addition, 71 groups responded. This included 40 conservation districts, 1 unit of Federal government, 8 units of State government, 13 units of local government, 6 farm organizations, 2 environmental groups and 1 academic institution.

Unfortunately, there was no clear posture by State government regarding RCA and the preferred program since no responses were received from the Governor or the two departments involved with natural resources, Department of Environmental Resources, and Department of Agriculture.

## GENERAL COMMENTS

Thoughts expressed included lack of public understanding of RCA, USDA didn't listen to the pubblic, questionnaire was biased, equal treatment for all responses and giving public opportunity to comment is a help. Five units of government and four conservation districts charged that the response form was biased.

## ATTACHMENT 3

## DISTRICT WORKSHEET

### Field Management

The purpose of the following section, Field Management, is for you to generalize what are the most prevalent "cropping systems", defined by three main factors--crops, tillage, and winter cover--and to describe the general fertilizer, herbicide, and conservation practices which characterize each cropping system in your district.

At first, it may seem impossible to aggregate the infinite combinations of farming practices in your district into a small number of cropping systems. It can be done, however, to provide an estimate of represententive farming activities for a given area; for a survey covering about 64,000 square miles, generalizations must be made.

Because data on the distribution of crops, tillage, and winter cover will be used to determine agricultural runoff loadings to the Chesapeake Bay and its tributaries, it is necessary to collect cropping system data by watershed, or by sub-basins (about 60 sub-basins cover the entire drainage area of the Chesapeake Bay). The sub-basin(s) in your district are delineated on the map provided.

It may be helpful to review the cropping systems described in the example worksheet. These are not meant to represent any specific area in the Bay region but instead are meant to provide you with an example of typical cropping systems broken-down by sub-basin.

To assist you in putting together the prevalent cropping systems in your district, we suggest that you work through the following process:

--On a separate piece of paper, write doem the crops grown in your district.

--What are the typical crop rotations?

--For each crop rotation, what is the major tillage practice used: conventional, minimum, or no-till?

--For cropland with each rotation, is residue generally left in place over the winter, or is it incorporated or removed?

You may work up a chart like the one shown on the following page:

| Crops | Rotations | Tillage | Cover (Sub-basin #) |
|---|---|---|---|
| Corn<br>Soybeans<br>Rye | Continuous Corn | 75% minimum-till<br>25% conventional | Residue left (1,2,3) |
| Tobacco | Corn/Rye/Soybeans | 100% minimum-till | Cover crop (rye) - yr 1<br>Residue left - yr 2<br>(1, 2, 3) |
| | Tobacco | 90% conventional<br>10% minimum | Residue removed (1,2) |

--By now, you may have a list of five or ten cropping systems that are the most prevalent cropping systems in your district. If any of them take up 10% or less of the cropland in your district, eliminate them.

--Next, refer to the map provided. As noted above, the sub-basins of your district are outlined and labeled. Some districts fall entirely within a sub-basin; others lie across several sub-basins. For reporting purposes, we would like you to estimate how the cropping systems that you describe are distributed among these sub-basins, in terms of percent of the total cropland in that sub-basin (see Question #1 below).

--This information will be used along with other data to estimate the nutrient loadings from agricultural runoff. For this reason, we would like some idea of the range of slope where each cropping system may be found. Also, your estimation of the soil losses from cropland in your district is no doubt better than any estimate we could make; please include, as best you can, the average annual soil loss to be expected from each cropping system in each sub-basin and the recommended "T" values for those lands. A chart to fill in this data is included in Question #1, Cropping System Information.

NOTE: For your convenience, a sample worksheet has been filled out to indicate the kind of answers we would like. Please look it over before beginning the worksheet. It is located at the back of this package.

In the spaces below, please describe the most prevalent cropping systems in your district.

| | Crops | Tillage | Winter Cover |
|---|---|---|---|
| System 1 | | | |
| System 2 | | | |
| System 3 | | | |
| System 4 | | | |
| System 5 | | | |

THE QUESTIONS WHICH FOLLOW SHOULD BE FILLED OUT SEPARATELY FOR EACH CROPPING SYSTEM LISTED ABOVE

Cropping System Information

Cropping System #______________

Description:

| Crops | Tillage | Cover |
|---|---|---|
| | | |

1. For this cropping system, complete the chart below with the following information:

   a) What percent of the cropland in Sub-basin 1 has this general system? Sub-Basin 2? Sub-Basin 3? Etc.

   b) For each sub-basin, indicate the range of slope where this system occurs.

   c) What is the average soil loss from cropland where this system is used?

   d) What is the recommended "T" value for these lands?

| Sub-Basin | % Cropland | Avg. Slope | Avg. Soil Loss | Recommended "T" Value |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

## 2. Planting and Harvesting Dates

For the crops grown what are the approximate planting and harvesting dates?

| Crop | Average Planting Date | Average Harvesting Date |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

## 3. Tillage Practices

In the chart below, state how often plowing, disking, or cultivating takes place and the approximate dates of each.

| | Number of Times/Yr. | Average Dates for Each |
|---|---|---|
| Plowing | | |
| Disking | | |
| Cultivating | | |

## 4. Fertilizer Usage

What is the typical fertilizer usage associated with this system? (Potassium is not included since it does not cause water quality problems.)

a) How many applications of nitrogen and phosphorus are applied in one season? Show approximate dates in each application.

b) How many pounds are applied in each application?

c) Briefly describe the method of application.

| Application | Date | Nitrogen (N) (lbs/Acre) | Phosphorus (P O ) (lbs/Acre) | Method of Application |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| | | | | |
| | | | | |

5. Manure

If manure is spread over cropland with this system, answer the following questions:

a) What type of manure is applied?____________________

b) Estimate the amount that is applied annually per acre.
____________________

c) How often is it applied (daily, monthly, seasonally, once/year)?
____________________

d) Describe the method of application:____________________

6. Herbicide and Pesticide Usage

Please fill out the chart on the following page as described:

a) For each crop, what are the typical herbicides/pestcides applied to fields with this system.

b) At what rates are they applied? Give dates for each application and describe the method used.

| Crop | Type | Application Date | Pounds/Acre | Method |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

7. **Present Conservation Practices**

Describe the conservation practices that are typical to this system in your district (e.g. contours, terraces, stripcropping, field borders, diversions, grassed waterways, impoundment ponds, tile drainage, surface drainage ditches, etc.). You may want to indicate the slopws and/or sub-basin on which they are located.

8. **Other Comments**

Additional comments that further explain this cropping system:

## CONSERVATION PLANNING AND NEEDS

The previous section on field management will help us understand just how far we have come along in terms of soil conservation. The following section is designed to summarize the extent to which more conservation practices are needed in your district.

Soil conservation has made great strides in keeping productive soils in place on farmland and out of streambeds. Today, however, approximately half of all sediment entering streams and rivers comes from agricultural runoff. There are, no doubt, fields in your district which you believe are losing too much soil. There also may be some water quality problems caused by animal wastes. However, practices that will reduce soil loss or control animal waste runoff have not been applied, for one reason or another.

Depending on the severity of existing soil losses and depending on the extent to which these losses are causing water quality problems, the costs to reduce soil loss to levels as low as the recommended "T" value may be prohibitive. For this reason, we have asked for the practices needed to achieve three levels of soil-loss reduction:

a) The highest level of soil-loss reduction
--to meet the recommended "T" value.

b) The intermediate level of reduction
--to reduce soil-loss to a level just above "T", or "T" + 2 tons/acre.

c) The lowest level of reduction
--to reduce soil-loss to "T" + 5 tons/acre.

To develop large scale plans for the improvement of water quality, the Chesapeake Bay Program (CBP) will generate a number of options, or management alternatives. The information produced from the following section will enable CFP to develop a set of management alternatives to reduce the impact of agricultural runoff on water quality. This worksheet will give estimates of the amount of farmland requiring remedial measures, and a range of solutions that address the problem to varying degrees. The costs to implement each solution alternative can be developed to help planners weigh the cost-effectiveness of one solution alternative compared to another.

Cost-effectiveness comparisons of agricultural control alternatices versus alternatives to control pollution from other sources (urban, industrial, municipal) can also be done. For example, planners may find that in a particular sub-basin of the Bay, it is more cost-effective to apply a medium-level of treatment to farmland (soil-loss reduced to "T" + 2 tons/acre) than to upgrade a sewage treatment plant; in other words, per dollar, a greater reduction is nutrient loadings can be achieved by applying the medium-level agricultural than by upgrading the treatment plant.

The questions that follow are broken out into the following categories:

Conservation Planning

- Farm Plans
- Leased Lands
- Agricultural Trends

Conservation Needs

- Cropland
- Hay and Pastureland
- Animal Wastes
- Feedlots, Barnyards, and Other Problem Areas

You are not expected to answer the following questions for individual sub-basins, except where specified; please estimate your responses on the district-level based on your working knowledge of the area.

## Conservation Planning

### Farm Plans

1. How many farms are there in your district?____________________
2. What percent of them have conservation plans?____________________
3. What percent of the plans are followed entirely?____________________

   partially?____________________

   not at all?____________________

   Explain why these values are high or low:____________________

4. How would you increase conservation on the land?____________________

## Leased Lands

1. Approximately how much farmland is leased?________

2. Are leased lands in your district farmed any differently than non-leased farmland?________ If no, go to the next section. If yes, describe the differences:________

3. What percent of leased lands, in terms of acreage, have conservation plans?________ If a significant number lack plans, explain reasons for the low percentage and suggest mechanisms to improve conservation practices on these lands.________

## Agricultural Trends

Briefly describe the agricultural trends in your district from World War II to present and trends you expect in the next 20 years for the following items:

1. Conversion of farmland to other uses.________

2. Conversion of marginal lands into farmland.________

3. Tillage practices.

4. Type of crops grown.

5. Farm machinery.

6. Average size of farm operation.

7. Chemical usage.

8. Irrigation.

9. Livestock and poultry operations.____________________

____________________

____________________

____________________

10. Policy and resource levels for soil and water conservation.____________________

____________________

____________________

____________________

11. Others.____________________

____________________

____________________

____________________

## Conservation Needs

### Cropland

1. How much farmland in your district needs additional treatment to achieve "T" + 5 tons/acre, "T" + 2, and "T"?

   "T" + 5 tons/acre? ____________________

   "T" + 2 tons/acre? ____________________

   "T" tons/acre? ____________________

2. What are the most common conservation practices you recommend to reduce the soil-loss to "T" + 5, "T" + 2, and "T"? What are the total costs?

|  | Practice | Total Cost |
|---|---|---|
| "T" + 5 |  |  |
|  |  |  |
|  |  |  |
| "T" + 2 |  |  |
|  |  |  |
|  |  |  |
| "T" |  |  |
|  |  |  |
|  |  |  |

### Hay and Pastureland

1. Is there a significant amount of soil-loss from hay and pastureland in your district? ____________________ If so, what percent of these lands need additional treatment to meet:

   a) "T" + 2 ____________________ b) "T" ____________________

2. What remedial measures would you recommend to reduce soil-loss on these lands, and what would be the total cost to apply them?

| | Practices | Total Cost |
|---|---|---|
| "T" + 2 | | |
| "T" | | |

Animal Wastes

1. Fill in the table below to show how many and what kind of livestock and poultry are in your district and approximately what percent of them are located in each sub-basin.

| Type | Number | % In Sub-Basin 1 | % In Sub-Basin 2 | % In Sub-Basin 3 |
|---|---|---|---|---|
| Cattle | | | | |
| Pigs | | | | |
| Sheep | | | | |
| Horses | | | | |
| Chicken | | | | |

2. Is there a problem in your district concerning animal wastes?________ If so, for what percent of the animals in your district are animal waste contrls needed?________________________. If this percent varies significantly among the sub-basins in your district, what percent of the animals need controls in each sub-basin?

Sub-Basin 1________________________________________

Sub-Basin 2________________________________________

Sub-Basin 3________________________________________

3. Specify the animal waste controls that are needed and the total cost to implement them.

| Practices | Total Cost |
|---|---|
| | |
| | |
| | |
| | |

Feedlots, Barnyards, and Other Problem Areas

1. Are there any other significant problems associated with feedlots, barnyards, or other problem areas in your district?______________ If yes, describe the extent of the problem, the remedial measures needed, and the total cost.

| Problem | Remedial Measures Needed | Total Cost |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

# APPENDIX D
# TOXIC COMPOUNDS

Daniel Haberman

Gail B. Mackiernan

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# CHLORINE

## INTRODUCTION

Chlorine has been used since 1902 as a means of disinfecting drinking water, and is considered one of the major factors reducing the incidence of water-borne disease in this (and other) countries (Greenberg 1980). Although not all human pathogens are equally sensitive to chlorine, it is still the disinfectant of choice because of its effectiveness, low cost, and ease of application. Furthermore, free chlorine has a relatively short residual time in ambient water, and is considered of low toxicity to man at concentrations used in drinking water treatment (Sugam and Helz 1977).

However, chlorine is a powerful oxidizing agent and biocide. In recent years concern has grown about the use of chlorine because of potential (or demonstrated) adverse environmental impacts and because of the formation of chlorinated organic compounds which may represent a human health hazard (Jolley 1975). One result of this concern has been a widespread reassessment of chlorine use, including the amount used, timing, or possible alternatives.

### Fate and Effects

Three major uses of chlorine today are disinfection of drinking water, disinfection of municipal and industrial wastewaters, and as an antifouling biocide within the heat exchange systems of steam electric generating plants. The latter two uses impinge directly on the estuary, and will be discussed below.

Present concern over use of chlorine has been generated by considerable work in the past 15 years on the toxicity and potential environmental effects, and on the chemistry of chlorine and toxicity of reaction products. A series of conferences on water chlorination have been summarized in three volumes published by Ann Arbor Science Press (Jolley 1978, Jolley et al. 1978, Jolley et al. 1980). These proceedings give an excellent overview of current research and findings on a variety of topics relating to chlorine use. Several conferences on chlorine use have been held in the Chesapeake Bay area (especially Block and Helz 1977, Chesapeake Bay Foundation 1982), and a number of review and summary reports have been issued by Bay research organizations and state institutions (e.g., Sugam and Helz 1977, Hall et al. 1981). A great deal of research on chlorine (and alternative biocides) has been sponsored in the Bay region by state and Federal agencies and other institutions; topics include the chemistry of chlorine in fresh and estuarine water, toxicity to a variety of native organisms, community effects, formation of reaction products, and toxicity and chemistry of alternatives to chlorine.

Environmental effects demonstrated (or postulated) include acute effects on organisms passing through power plant condenser systems where elevated temperatures exacerbate the situation (e.g., Burton et al. 1979) or near-field effects due to exposure to the effluent plumes from chlorine dischargers (Bellanca and Bailey 1977). Laboratory studies have shown sensitivity to relatively low concentrations of chlorine on the part of eggs, larvae, and juvenile fish (e.g., Morgan and Prince 1977), oyster and clam larvae (e.g., Roosenburg et al. 1980a, 1980b)), zoo- and phytoplankton (e.g., Heinle and Beaver 1977, Heinle and Beaver 1980; Mackiernan et al. 1978), and many other organisms (e.g., Roberts et al. 1975). Exposure to low levels of chlorine has produced community changes in phytoplankton and benthic organisms in microcosms (Sanders and Ryther 1980, Sheridan and Badger 1981). Avoidance of chlorinated effluents by migrating fish -- and thus potential blockage of spawning runs -- has been postulated (e.g., Tsai 1970, Meldrin and Fava 1977). Most of these effects have been demonstrated under controlled conditions; showing similar impacts in the field has been less simple.

One difficulty is the complex behavior of chlorine in fresh and estuarine waters (Sugam and Helz 1977, Helz et al. 1980, Helz 1981). Briefly, in fresh waters, free chlorine reacts with water to form hypochlorous and hypochloric acid. These react rapidly with ammonia and organic amines to form chloramines. Together, these compounds constitute "total residual chlorine" (TRC). Measured values of TRC are usually less than the amount of chlorine added as a dose, the difference being due to the chlorine demand of the water (Helz 1981). The magnitude of chlorine demand depends on time elapsed, dose, temperature, and characteristics of the receiving water (Helz 1981). Chlorine is also lost through dissipation to the atmosphere. Slower reactions may form a variety of chlorinated products with organic material, metals, nitrite, etc. (Helz 1981). In estuarine and sea waters, which contain significant amounts of bromide (and some iodide), a different pathway exists. Bromide is rapidly oxidized by chlorine to form hypobromous and hypobromic acids; these are also oxidative and biocidal compounds (Helz 1981). The oxidants formed by the chlorination of saline water are collectively termed "chlorine-produced oxidants" (CPO). Bromamines and, eventually, a variety of brominated organic and other compounds are formed (Helz 1981). This is the dominant pathway for chlorine added to water of about 5 ppt salinity and above (Helz 1982). All of these reactions can lead to the formation of some toxic halogenated compounds, the exact nature of which depends on the chemical composition of the treated water, as well as such variables as pH, temperature, and salinity (Helz 1982). (A detailed discussion of the formation, composition, and effects of these secondarily-produced compounds are contained in the water chlorination series cited above.) Free chlorine, TRC, and CPO are rapidly dissipated in the environment, and concentrations soon fall below the level of detection of most routinely used instrumentation. However, toxic effects have been demonstrated in the laboratory at concentrations at or below the usual "level of detection." Environmental consequences of such low concentrations remain unclear.

## Current Programs and Strategies for Reduction of Chlorine

Because of the demonstrated toxicity of chlorine to estuarine organisms, and the potential harm to the environment, there has been a reassessment of the use of chlorine in the Bay area. There has been a move toward reduction of chlorine residuals, site-specific evaluations of use of chlorine, and consideration of environmental effects in siting and permitting of dischargers. Impetus has come from the Federal government, chiefly through the EPA, but also from the USF&WS, the NMFS, from strong commitments from both Maryland and Virginia, and from many parts of the private sector. Control strategies focus on three approaches: 1) reduction or elimination of chlorination (the latter also implies use of no biocides); 2) use of alternative biocides; and 3) reduction of the impact of effluents, including dechlorination.

In a national survey conducted by the Virginia State Water Control Board, Maryland was identified as one of two states that was doing the most to reduce the use and impacts of chlorine through a variety of approaches.[1] Presently, a Disinfection Task Force has been formed in Virginia to assess the use of chlorine, and to make recommendations to the state on the use of this and other biocides (VA SWCB 1983b).

Both Maryland and Virginia have existing quidelines for discharges of chlorine in municipal and industrial effluents. This may be specified by an NPDES permit or a consequence of a receiving water quality standard. In Maryland, the discharges of chlorine to natural trout waters are prohibited, and discharges to class 4 waters (recreational trout waters) cannot exceed effluent concentrations of 0.02 mg $L^{-1}$, with a maximum of 0.002 mg $L^{-1}$ allowable in the receiving water; the maximum concentration allowable in effluents discharged to other waters is 0.5 mg $L^{-1}$. The latter concentration limit may be reduced in discharge permits depending on particular aspects of the receiving water (e.g., nearness to an important spawning area, etc.) (MD OEP 1983). In Virginia, permitted chlorine residuals in effluents for STPs discharging to shellfish waters are 1.5 to 2.5 mg $L^{-1}$, for other waters 1.0 to 2.0 mg $L^{-1}$. An "anytime" maximum of 4 mg $L^{-1}$ in the effluents of STPs is specified in NPDES permits (VA SWQB 1983). At least a 1:20 dilution at the point of discharge is recommended to reduce residual chlorine levels to approximately 0.02 mg $L^{-1}$ in nearfield receiving waters (Select Interagency Agency Taskforce on Chlorine 1979). Both Maryland and Virginia have ongoing programs dealing with chlorine use in STPs; these will be discussed in the section on "current programs." In both Virginia and Maryland, industrial dischargers of chlorine have permitted effluent limits identical to that of municipal STPs; the difference is that, in Virginia, no exceptions to these limits are allowed in permits, as is the case with municipal STPs. Very small dischargers are currently not closely regulated, except that a fecal coliform limit exists for wastewater from seafood processors in Maryland. There is some effort underway to reduce or improve chlorine use at these plants; this will be discussed below.

Steam-electric power plants are currently licensed to have effluent limitations of 0.2 mg $L^{-1}$, or less, at the point of discharge as a 24-hour average, with a 0.5 mg $L^{-1}$ maximum allowed for some (in Maryland, class 1 or 2 waters). Current rewriting of discharge permits requiring BAT will probably result in maximum effluent limitations of 0.2 mg $L^{-1}$ TRC.[2]

---

[1] Personal communication: "Chlorine Control Strategies in Various States", A. Pollack, VA. State Water Control Board, 1983.

### Reduction (or Elimination) of Chlorination--

Reduction of chlorine use presents different problems for sewage treatment facilities (where a public health concern exists) than for power plants. In both cases, however, decreasing chlorine use has to be balanced against perceived needs of the user.

Strong differences of opinion exist as to the necessity of disinfecting effluents of STPs. It is often cited that in many European countries, chlorination of secondarily-treated wastewaters rarely occurs (Coughlan and Whitehouse 1977, Garnett 1982). However, in the opinion of local state agencies concerned with public health, disinfection of effluents discharged to natural waters remains a necessity (MD OEP 1982, Oliveri 1982). Recommended strategies to reduce chlorine include a site-specific evaluation to determine if public health risk necessitates disinfection, or whether seasonal disinfection or no disinfection is possible (MD OEP 1982). This evaluation would be based on the quality of the receiving water or its potential uses.

### STP Case Study: Operation DO-IT--

In 1977, a Chlorine Residual Control Advisory Committee in Maryland recommended that the best first step in reducing chlorine residuals would be to improve and upgrade existing treatment facilities (Silberman and Kruse 1977). In the same period, concern grew over the potential effects of chlorine on spawning anadromous and semianadromous fish. In 1981, the Maryland Department of Health and Mental Hygiene and the Department of Natural Resources joined together in a project called Operation DO-IT (Disinfection-Optimization-Innovative Techniques) to improve existing chlorination facilities and to reduce the amount of chlorine discharged to fish spawning areas (Garreis and Parrish 1982). Forty wastewater treatment plants were identified by DNR as potentially impacting spawning fish. These were examined by a special team, and a case-by-case assessment made of needed modifications to the chlorination facilities. Twenty-two plants (55 percent) were found to require some modification. The team worked with the plant owner/operator to make on-site modifications and to help implement improved operation procedures. Deficiencies which were identified and corrected included inadequate chlorine diffusers, poor location of diffusers, over-dosing, and poor control of flow. Effectiveness of the modifications and the subsequent achievement of good disinfection were measured by coliform levels remaining in the final effluent (Garreis and Parrish 1982). Costs for operation DO-IT ranged from 75.00 to 245.00 dollars per plant.

In plants where modifications could not reduce effluents to the desired 0.5 mg $L^{-1}$ TRC, temporary dechlorination equipment was installed. Details of this project, Operation TIDE, are discussed later in a section on dechlorination. Together in the first year, DO-IT and TIDE reduced chlorine residuals by an average 66 percent in nine river basins.

---

[2] Personal Communication: "Chlorine Effluents at Virginia Power Plants," M. Brehmer, VEPCO, 1983.

In some areas, over 90 percent reduction occurred. A major positive result was that these projects focussed the plant operators' attention on the problem, and achieved excellent cooperation between treatement plant owners and the state (Garreis and Parrish 1982). This is emphasized by the point that in 1983, when no state funding was available for the projects, all but two STPs of the original 40 continued to participate.[3]

Industrial Case Study--
A private sector initiative to reduce chlorine use at seafood packing houses in Virginia was begun by Morgan and Sons, Inc., a seafood company of Weems Virginia, in conjunction with Duboise Corp. and other interested parties. A series of meetings was held with plant managers to familiarize them with alternatives to chlorine use for sterilizing their facilities during seafood processing. Some 22 houses (out of 227 in Virginia) are now using these alternative methodologies. Although initial set-up costs per house were relatively high, after several years the savings have been considerable due to increased effectiveness and efficiency.[4]

Power Plants--
Power plants usually initiate chlorination in mid-May when biofouling becomes a problem. This is after major fish spawning runs. However, there is still some concern over the biological effects of power plant effluents (VA DTF 1982). The major difficulty in reducing chlorination for plants where significant biofouling occurs is the increased maintainence costs and downtime (Roig, 1982 ). It is estimated that cleaning a fouled unit at a larger plant (e.g., Chalk Pt. or Wagner) requires 3 to 5 days at a cost of 150 to 300 thousand dollars a day (Roig 1982 ). In some areas, where chlorine discharges are thought to have negative impacts, the use of cooling towers rather than once-through cooling is possible. For example, the Vienna plant on the Nanticoke, discharging into a major striped bass spawning area, has replaced its once-through units with a cooling tower. Whether further reduction in chlorine use at Bay power plants can occur is problematic. Alternatives have been investigated, however (Helz and Kosak-Channing 1980).

Whether or not chlorination is used, most plants use Amertap, a mechanical abrasive process using rough sponge balls circulating in the cooling water. For some major facilities (e.g., Calvert Cliff NPP) Amertap and other mechanical methods are sufficient. A variety of alternative nonchemical or mechanical techniques have been suggested for the control of fouling (Garey 1980, Burton and Hall 1982). Some of these (such as heat) are successfully used on the West Coast; however, few plants can be retrofitted for this capability (Garey 1980). This should be considered in future plant design, however.

## Use of Alternative Biocides

Substitute biocides investigated for sewage treatment plants include

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[3] Personal communication: "Operations DO-IT and TIDE in 1983", M. Garreis, MD OEP, 1983.

[4] Personal communication: "Cost and Effectiveness of Alternative Disinfection Methodologies", C. Morgan, Morgan and Sons, Inc., 1983.

BrCl (bromine chloride), $H_2O_2$ (hydrogen peroxide), $O_3$ (ozone), and ultraviolet light. The first three could also be used for antifouling in power plants. They are also strong oxidants and, hypothetically, could behave similarly to chlorine in estuarine water (Helz and Kosak-Channing 1980). The advantages of ozone in freshwater are that it degrades very quickly (Schlimme 1982); but, in estuarine waters, it reacts with bromide to form a variety of halogenated compounds (Helz et al. 1978). Results of toxicity studies indicate that these ozone-produced oxidants are similar to CPO in their effects on oyster and striped bass larvae (Stewart et al. 1979, Hall et al. 1981). BrCl has probably received the greatest attention as an alternative disinfectant. The major advantage of BrCl is that decay of its residuals is much more rapid than chlorine, eliminating the need for dechlorination prior to discharge (LeBlanc 1982). This also creates a disadvantage, because as the quality (i.e., clarity, low concentration of suspended solids and organics) of the STP effluent declines, more BrCl is needed to achieve satisfactory disinfection (LeBlanc 1982). Roberts and Gleeson (1978) found BrCl to be two to four times less toxic than chlorine to a variety of endemic Chesapeake Bay species. An in situ study at Morgantown SES found no significant differences between the survival of estuarine fish exposed to very low BrCl or $Cl_2$ concentrations (levels sufficient to control biofouling in the condensor tubes)(Linden and Burton 1977). Ultraviolet light requires a very clean effluent to be effective but has the advantage of producing no chemical residues, and can also be less expensive to operate than conventional chlorination equipment (Alpert and Bonomo 1982).

### Current Programs

At the present time, Maryland is using alternative biocides at a number of sewage treatment facilities: approximately 10 percent of plants use ultraviolet light (mostly freshwater), and one small plant is using BrCl. A relatively large (8 MGD) plant also tried BrCl, but had problems with finding a consistent supply of the chemical, and in achieving consistent disinfection results. It has since returned to chlorination-dechlorination.[5]

In Virginia, promising tests have been made on the efficacy of BrCl by the Hampton Roads Sanitary Commission (LaBlanc 1982). This and other alternative biocides are being evaluated by the ongoing Disinfection Task Force.

### Techniques to Reduce the Impact of Effluents--

A number of techniques have been proposed to reduce the impacts of chlorinated effluents: seasonal disinfection, holding lagoons, and dechlorination. The latter has received the most attention. Neither Maryland nor Virginia presently permit seasonal disinfection, but many other states have seasonal discharge permits.[6] This strategy is being investigated by both states as a possibility for waters where only seasonal public health concerns may arise (e.g., swimming and boating). Holding lagoons, land disposal of effluent, and similar techniques are discussed by Wheeler (1982). Many have been funded under the EPA's Innovative Alternative Program.

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[5] Personal communication: "Use of Akterbatuve Biocides in Maryland." M. Garreis, MD OEP. 1983.

[6] Personal communication: "Seasonal Discharge Permits for Chlorinated Effluents in MD and VA." A. Pollack, VA SWCB. 1983.

Dechlorination is currently used in about 35 percent of Marylands' STPs; Virginia has two small plants now operating with dechlorination, and three major STPs coming on line shortly. Although dechlorinated effluents still possess residual toxicity compared to controls (Hall et al. 1981); this toxicity is significantly less than that caused by TRC. This residual toxicity may be due to the production of halogenated organics before the dechlorination step. Effects of the addition of another chemical (usually $SO_2$) to the effluent/water are as yet unknown (Greene 1982).

Case Study: Operation TIDE--

Operation TIDE (Temporary Installation of Dechlorination Equipment), was coupled with the previously described Operation DO-IT in a joint effort by Maryland DHMH and DNR to reduce chlorine residuals from STPs discharging to major estuarine and freshwater fish-spawning areas (Garreis and Parrish 1982). After an upgrading of facilities under DO-IT, those plants where residuals still did not meet the desired 0.5 mg $L^{-1}$ TRC level had temporary dechlorination facilities installed. In addition, plants which had holding lagoons were encouraged to draw down water levels in advance of the project and to hold effluents for 30 to 60 days depending on the reserve capacity available (Garreis and Parrish 1982). During the peak of spawning (April 15 to May 15), no discharge from these lagoons occurred. Operation TIDE involved 34 of the original 40 plants, six of these had holding lagoons. Dechlorination equipment (sulfur dioxide or sodium metabisulfite) was installed at the remaining 28 wastewater treatment plants.

As discussed previously, Operations DO-IT and TIDE resulted in an overall reduction in total chlorine residuals discharged by some 66 percent. This represents the time period from April 1 to June 1, 1981. Not all plants were able to install equipment by April first; therefore, 100 percent reduction was not achievable at all locations (Garreis and Parrish 1982). Project costs for TIDE ranged from a low of 250 dollars to a high of 4,000 dollars per plant; total costs for TIDE were 26,700 dollars in 1981. The WSSC absorbed the cost of installing and operating dechlorination facilities at three major plants.

In 1982, Operation TIDE was emphasized as the modifications installed under DO-IT were still in place. In 1983, 38 of the 40 plants are still participating although state funds are no longer available.

Whether DO-IT and TIDE will result in significant improvement in fish spawning and recruitment has not yet been determined. The year 1981 was a poor year; 1982 was a relatively good year for recruitment of freshwater-spawning species. Data in succeeding years may help evaluate the contribution of these innovative programs.

Other Current Programs--

Field evaluations of the effects of chlorination/dechlorination and chlorination versus ultraviolet light treatment have been proposed by both Maryland and Virginia. These will involve monitoring changes taking place in the receiving environment when sewage treatment plants switch from chlorination to ultraviolet disinfection, from chlorination to dechlorination (or cease dechlorinating), when plants cease operation, and when plants begin operation in an area previously not exposed to STP effluents. Such field manipulations will enable managers to evaluate different disinfection procedures, as well as the magnitude, nature, and time-scale of environmental responses.

## SECTION 2

## BIOLOGICAL MONITORING

The CBP recommends that a biomonitoring protocol be included in the NPDES permitting system. A biomonitoring program can be used for controlling those toxicants which pose environmental dangers to the aquatic environment. The advantages of developing this new program are;

- it is not limited to priority pollutants,
- it considers synergistic effects,
- it is not bound by control technology, and
- it is a reasonable indicator of toxicity in the receiving water.

### BASIS FOR BIOMONITORING

Biological toxicity testing can overcome many of the limitations which have prevented the effective control of potentially harmful effluents. Developing a framework to better control toxicants is a major objective of the Chesapeake Bay Program. Individual or combinations of complex chemical compounds which pose a hazard to human and aquatic health must be rapidly identified and limited to safe concentrations. Regulations of specific substances must be based upon known harmful biological effects observed in the environment.

Toxicity-based permits can overcome the limitations of both Best Available Technology (BAT) controls and receiving water quality standards. Current discharge limits for industrial effluents based on BAT do not recognize all toxicants in the waste stream. The weakness of laboratory-based water quality standards is that they cannot consider all of the natural variations in aquatic environments or local water quality, nor do they take into account effects due to the presence of multiple toxicants, as occurs in many effluents. For these reasons effluent toxicity testing can provide a more inclusive and realistic assessment of the constituents in wastewater and their potential for harm in the environment.

### CASE STUDY: THE MONSANTO PROTOCOL

The protocol developed by Monsanto Research Corporation (MCR) (Wilson et al. 1982) can be used to identify those industrial and municipal effluents which pose the most significant danger to aquatic life. It involves a series of progressively more sophisticated tests and is designed to identify the most "harmful" effluents from a scan of dischargers. Therefore, those effluents which contain a substance, or a combination of substances, which is acutely toxic to aquatic species, bioaccumulative, and contains significant quantities of organic compounds is immediately recognized. Effluents which do not indicate an immediate danger to aquatic health can be investigated to the level required under the pollution control requirements of current legislation.

Sediment analysis can also be used to investigate the impact of a particular source on a local or regional environment. Researchers found correlations between compounds in proportional amounts for most sediment/effluent pairs that were tested. These sediment analyses alone are not particularly useful for evaluating existing discharges but are good indicators of the adsorbtion and accumulation of compounds in the sediments.

The basic, intermediate, and advanced stages of effluent analysis used in the Monsanto toxicity protocol are shown in Chapter 4. This decision tree is used to evaluate the toxic effects to aquatic species, the presence of bioaccumulative compounds, and significantly high concentrations of organic compounds. The sequential extractions and bioassays also serve to identify the substance(s), or class of substances, responsible for the observed toxicity.

The results of the tests for the acute toxicity to aquatic species from municipal and industrial effluents are shown in Tables 1, 2 and 3. Further details are included in Chesapeake Bay Program Technical Studies: A Synthesis (Bieri et al. 1982) and in Wilson et al. 1982.

TABLE 1. TOXICITY OF MUNICIPAL EFFLUENTS (WILSON ET AL. 1982)

| Plant Code | Type | State | Toxicity | | High Organic Content | | High Bioaccumulative Content | |
|---|---|---|---|---|---|---|---|---|
| | | | Rating | Possible Cause | Yes/No | Possible Cause | Yes/No | Possible Cause |
| B 141 S | STP | MD | High | ammonia, Cr, organics | yes | chlorinated aromatics | yes | substituted naphthalenes |
| C 150 D | STP | VA | Mod. | chlorine, metals | yes | ? | yes | chlorinated benzenes |
| C 155 D | STP | VA | High | chlorine, ammonia | yes | substituted benzenes | no | - - |
| C 156 D | STP | VA | Mod | chlorine, metals | yes | chlorinated hydrocarbons | yes | dichlorobenzene<br>pentachlorophenol,<br>dichlorotoluene |
| C 158 D | STP | VA | Low | chlorine, metals | no | - - | no | - - |
| C 161 D | STP | VA | High | chlorine, metals, organics | yes | substituted benzenes | yes | chlorinated benzenes and toluenes |
| C 164 D | STP | VA | High | chlorine, acrylonitrile | yes | acrylonitrile | no | - - |
| C 169 D | STP | VA | Mod. | ammonia | yes | ? | no | - - |

TABLE 2. TOXICITY OF INDUSTRIAL EFFLUENTS (WILSON ET AL. 1982)

| Plant Code | Type | State | Toxicity Rating | Toxicity Possible Cause | High Organic Content Yes/No | High Organic Content Possible Cause | High Bioaccumulative Content Yes/No | High Bioaccumulative Content Possible Cause |
|---|---|---|---|---|---|---|---|---|
| A 101 | I | VA | None | - - | no | - - | no | - - |
| A 109 | I | VA | Mod. | ammonia, Cr | yes | amines | yes | chlorinated cyclohexenes |
| B 111 D | I | VA | None | - - | yes | - - | no | - - |
| B 112 D | I | VA | Mod. | metals | no | - - | yes | carbazole, biphenyl, chlorophenols, PNAs |
| B 113 D | I | VA | None | - - | - | - - | - | - - |
| B 119 D | I | VA | Mod. | Cu, chlorine | yes | phenol & alcohol based organics | yes | biphenyl and unknowns |
| B 124 D | I | VA | Mod. | chlorine, metals, cyanide | yes | chloroform | no | - - |
| B 126 S | I | MD | High | Cd, ammonia | no | - - | no | - - |
| B 133 S | I | MD | Mod. | ? | yes | ? | no | - - |
| B 142 S | I | MD | High | cyanide, Cu, organics | yes | chlorinated aromatics | no | - - |
| B 143 S | I | MD | Mod. | Mn | no | - - | no | - - |
| B 147 S | I | MD | Mod. | Cd, Cu | no | - - | no | - - |
| B 149 S | I | MD | High | Cr, Pb | yes | chlorophenols | yes | biphenyl substituted naphthalenes |
| C 151 D | EPG | VA | Mod. | chlorine, metals | no | - - | no | - - |
| C 153 D | I | VA | None | - - | no | - - | no | - - |
| C 154 D | I | VA | High | Cr, Pb | no | - - | no | - - |
| C 157 D | I | VA | Low | ? | yes | ? | no | - - |
| C 159 D | I | VA | Mod. | ammonia metals | no | - - | no | - - |
| C 160 D | I | VA | None | - - | no | - - | no | - - |
| C 169 S | I | MD | High | Cr, chlorinated hydrocarbons | no | - - | no | - - |

| | |
|---|---|
| - - | not applicable |
| STP | Sewage Treatment Plant |
| I | Industrial Source |
| EPG | Electric Power Generation |
| ? | unknown |

TABLE 3. TOXICITY OF COMMERCIAL ELECTRIC POWER GENERATING PLANT

| Code | Plant Rating | Toxicity Possible Cause | High Organic Content | | High Bioaccumulative Content | |
|---|---|---|---|---|---|---|
| | | | Yes/No | Possible Cause | Yes/No | Possible Cause |
| C 151 D | Mod. | chlorine, metals | no | - - | no | - - |

| | |
|---|---|
| - - | not applicable |
| STP | Sewage Treatment Plant |
| I | Industrial Source |
| ? | unknown |

## SECTION 3

# FINGERPRINT FILE

## FINGERPRINTING USING GAS CHROMATOGRAPHY

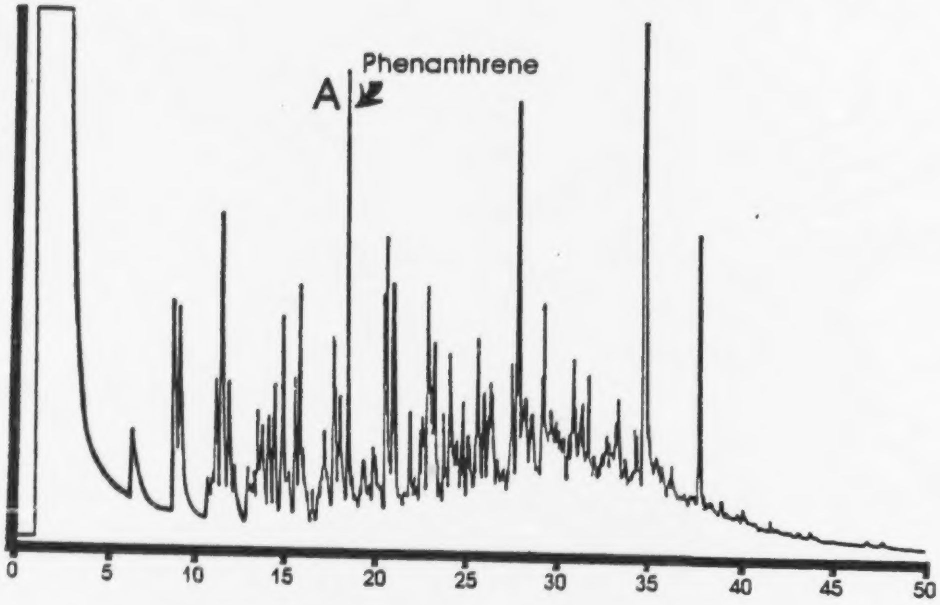
To identify and control hazardous toxicants in the environment, it is necessary to use analytical techniques which can detect the presence of known and unknown compounds that may be present in quantities which are sufficient to cause environmental harm. Typically, these screening techniques can be used to gather baseline data or search for the possible cause of an observed event.

When effluent, sediment, or tissue samples containing unidentified compounds pass through the gas chromatograph column and detector, each individual compound is identified by its "retention time." Compounds of low molecular weight pass through relatively faster than more complex, heavier compounds. The final pattern of peaks on the chromatogram reveals both the compounds present and their quantity. Figure 1 shows a typical chromatogram of Chesapeake Bay sediment.

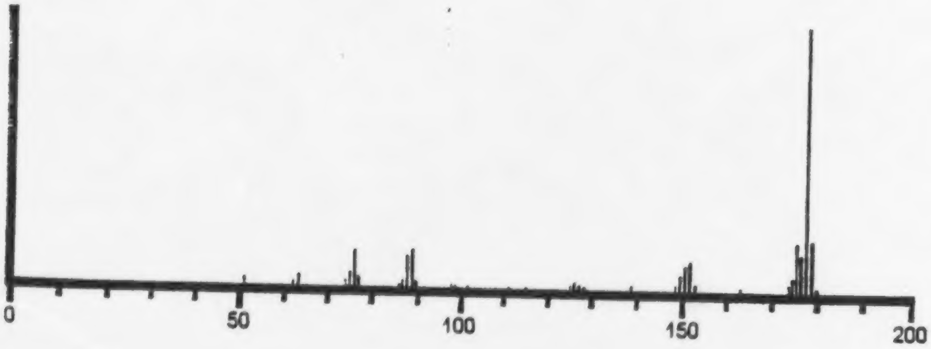
Fingerprinting techniques developed by CBP investigators modify basic gas chromatographic techniques and eliminate many of the common problems associated with identification using mass spectrometry (Bieri et al. 1981, 1982). For example, sediment samples rarely exhibit a "clean" fragmentation pattern but instead a dense, overlapping series of peaks that are difficult to quantify. The results of a comparison with the mass spectral data files rarely show perfect matches and spectra can be masked within an unresolved envelope. Therefore, interpretation by highly skilled chemists is necessary to determine what constititues a successful match. Additionally, retention times vary significantly between different instruments and even between different chemists on the same instrument.

One important modification recommended by the CBP involves co-injection of marker compounds with the sample. By including these normalized identifiers, a relative retention number can be tagged to other peaks in the sample. This eliminates differences created by using straight retention times that have been developed and interpreted on different instruments. Search procedures for known compounds during GC/MS analysis are simplified and the very large number of unknown compounds can be noted and logged for future reference. Identification and separation of peaks is substantially improved by the use of capillary column GC/MS instead of packed column GC/MS. The sum of tagged peaks, representing known and unknown compounds, is termed a "fingerprint".

These procedures allow investigators not only to search for compounds beyond those specifically permitted or known to exist, but to place that particular fingerprint into a more comprehensive analysis of changes over time and geographic area. A computer program designed to compare chromatograms, determine concentrations, and scan for specific compounds (based on specific retention times) was developed to facilitate analysis. Details of analytical procedures and computer programs can be obtained from Bieri et al. 1981 and 1982. This approach allows, for example, a "search" of filed effluent chromatograms for those showing certain compounds identified from the analysis of sediments or animal tissues.



Gas Chromatograph or "Fingerprint" showing location of phenathrene.



Mass Spectrograph of Phenathrene.

Figure 1. "Fingerprint" and mass spectrograph showing phenanthrene.

SECTION 4

# DATA TO CALCULATE METAL LOADS

TABLE 4. DATA NECESSARY TO CALCULATE LOADINGS OF METALS FOR URBAN AREAS (BIERI ET AL. 1982a)

A. Average metal loading (mg $L^{-1}$) for urban areas.

| | Pb | Zn | Cu | Mn | Fe | Cr | Cd | Ni |
|---|---|---|---|---|---|---|---|---|
| LLSF[1] | .11 | .09 | .016 | .035 | 2.47 | .021 | .01 | .059 |
| MDSF[2] | .21 | .096 | .016 | .023 | 1.34 | .018 | .009 | .028 |
| THGA[3] | .26 | .123 | .019 | .057 | 1.78 | .017 | .001 | .025 |
| Comm-Ind[4] | .39 | .22 | .025 | .027 | 2.50 | .017 | .004 | .044 |

B. Acreage and runoff volumes for Baltimore, Norfolk, and Washington, DC

| | Baltimore | | Norfolk | | Washington, DC | |
|---|---|---|---|---|---|---|
| | acres | vol. runoff | acres | vol. runoff | acres | vol. runoff |
| LLSF | 47,411 | 7.09 | 31,661 | 7.22 | 120,987 | 6.79 |
| MDSF | 19,131 | 11.49 | 11,068 | 11.71 | 29,828 | 11.01 |
| THGA | 20,920 | 19.54 | 11,317 | 19.92 | 16,869 | 18.72 |
| Comm-Ind | 13,309 | 29.29 | 12,448 | 29.86 | 22,280 | 28.06 |

C. Example: Pb loading at Baltimore

| | Acres | Vol. runoff in/$acre^{-1}$/$yr^{-1}$ | Avg. Pb loading mg/$L^{-1}$ | Conversion factor | Total (lbs/day) |
|---|---|---|---|---|---|
| LLSF | 47,411 | 7.09 | .11 | $7.27 \times 10^{-4}$ | 26.9 |
| MDSF | 19,131 | 11.49 | .21 | $7.27 \times 10^{-4}$ | 33.2 |
| THGA | 20,920 | 19.54 | .26 | $7.27 \times 10^{-4}$ | 77.1 |
| C-I | 13,309 | 29.29 | .39 | $7.27 \times 10^{-4}$ | 110.3 |
| | | | | | 247.5 |

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[1] Large lot single family residential (0.1 - 2.0 D.U./acre)

[2] Medium density single family residential (2.0 - 8.0 D.U./acre)

[3] Townhouse/garden apartment (8.0 - 22.0 D.U./acre)

[4] Commercial Industrial

# SECTION 5

# METHODS FOR CALCULATING COPPER OFFLOADINGS FROM ANTI-FOULING PAINTS

## TABLE 5. TWO METHODS FOR CALCULATING LOADINGS OF COPPER FROM ANTI-FOULING PAINTS

### A. Total pounds of copper applied to registered boats

1. Analysis of Registration Data

| State | Year | Total Registration | # boats in tidewater | less than 16 ft. | 16-26 ft | greater than 26 ft. |
|---|---|---|---|---|---|---|
| MD | 1981 | 134,105[a] | 133,074[c] | 61,310[d] | 57,111[d] | 13,569[d] |
| VA | 1982 | 139,694[b] | 65,000 | 33,150 | 28,600 | 2,600 |

2. Total number of non-aluminum boats which require anti-fouling paints

| State | Less than 16 ft. | 16 - 26 ft. | greater than 26 ft. |
|---|---|---|---|
| MD | 35,516[e] | 52,637[e] | 13,268[e] |
| VA | 19,227[f] | 26,312[f] | 2,548[f] |
| Total | 54,743 | 78,949 | 15,816 |

3. Anti-fouling paint (and copper) application rates

| | Less than 16 ft. | 16 - 26 ft. | greater than 26 ft. |
|---|---|---|---|
| Number of boats | 54,743 | 78,949 | 15,816 |
| Avg. gal. per year | .25 | .50 | 1.5 |
| Total gallons | 13,685 | 39,475 | 23,724 |
| at 4.6 lbs/Cu/gal.[1] | 62,951 | 181,585 | 109,130 |

| | |
|---|---|
| TOTAL lbs/Cu/Yr. | 353,666 |
| TOTAL lbs/Cu/day | 969 |

### B. Total Copper necessry to maintain 10 ug/$cm^2$/day and leaching rate and prevent fouling

| Size | Number of boats in Md and VA | Avg/$ft^2$/ship | leaching rate[2] (lbs/$ft^2$/day) | Total lbs/day |
|---|---|---|---|---|
| less than 16 feet | 54,743 | 100 | $2.0 \times 10^{-5}$ | 109 |
| greater than 16 feet | 94,765 | 200 | $2.0 \times 10^{-5}$ | 379 |
| | | | | 488[g] |

Footnotes to Table 5

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[a] MD registration

[b] VA registration

[c] All boats in MD except 1,031 in Garrett County

[d] Numbers from Maryland registration data

[e] Aluminum hulls removed from calculation (from MD registration data).

[f] Same percent used for VA

[1] Young et al. 1979

[2] $10 ug/cm^2/day \times 2.2 \times 10^{-8}$ lbs/10ug $\times .00108\ ft^2/cm^2 = 2.0 \times 10^{-5} lbs/ft^2/day$.

[g] A leaching rate of 488 lbs of copper per day requires the application of 106 gallons of paint per day or 38,690 gallons per year.

# SECTION 6

# INDUSTRIAL METAL LOADS FOR 1980

TABLE 6. 1980 INDUSTRIAL METAL LOADS TO CHESAPEAKE BAY

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | METAL LOAD (LBS/DAY) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | CADMIUM | CHROMIUM | COPPER | LEAD | ZINC |
| E SHORE | DELMARVA P&L VIENNA | 94 | MD | . | 0.01 | 0.00 | 0.02 | |
| E SHORE | ELECTRO-THERM INC | 1007 | MD | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 |
| E SHORE | NATIONAL CAN CORP CAMBRIDGE | 2801 | MD | 0.83 | 0.00 | 0.01 | 0.00 | 2.92 |
| E SHORE | RMR CORPORATION | 54178 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| E SHORE | SOLVENT DISTILLERS,INC. | 3387 | MD | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 |
| E SHORE | TENNECO CHEMICALS INC | 345 | MD | 1.22 | 3.25 | 13.41 | 7.31 | 13.80 |
| JAMES | ALLIED CHEM CORP, HOPEWELL | 5291 | VA | 0.16 | 4.74 | 0.84 | 1.81 | 8.61 |
| JAMES | ALLIED CHEMICAL CORP | 5312 | VA | 0.01 | 0.25 | 0.04 | 0.10 | 0.24 |
| JAMES | ATLANTIC CREOSOTING CO INC | 4189 | VA | 0.00 | 0.01 | 0.08 | 0.02 | 0.22 |
| JAMES | CENTRAL OIL ASPHALT CORP | 54330 | VA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JAMES | E I DUPONT DE NEMOURS & CO | 4669 | VA | 0.05 | 1.49 | 0.27 | 0.57 | 1.45 |
| JAMES | E I DUPONT DE NEMOURS & CO | 4880 | VA | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 |
| JAMES | EXXON CORP-RICHMOND ASPHALT TE | 56146 | VA | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 |
| JAMES | FIRESTONE SYNTHETIC, HOPEWELL | 3298 | VA | 0.00 | 0.05 | 0.01 | 0.02 | 0.05 |
| JAMES | GENERAL METALS TECHNOLOGIES CO | 56804 | VA | 0.12 | 0.56 | 0.41 | 0.06 | 0.41 |
| JAMES | HAMPTON ROADS ENERGY COMPANY | 53171 | VA | 0.01 | 0.35 | 0.06 | 0.13 | 0.64 |
| JAMES | INTA-ROTO, INC | 55280 | VA | 0.00 | 0.01 | 0.01 | 0.03 | 0.01 |
| JAMES | NAROX INC. | 50962 | VA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| JAMES | NATL CYLINDER GAS DIV CHEMETRO | 3689 | VA | 0.00 | 0.01 | 0.01 | 0.09 | 0.00 |
| JAMES | NAVAL SUPPLY CENTER CRANEY FAC | 5487 | VA | 1.18 | 2.81 | 4.14 | 0.59 | 2.81 |
| JAMES | NAVY NORFOLK SHIPYARD | 5215 | VA | 4.73 | 11.22 | 16.54 | 2.36 | 11.22 |
| JAMES | NEWPORT NEWS SHIPBUILDING & DR | 4804 | VA | 3.92 | 9.62 | 13.87 | 2.71 | 9.30 |
| JAMES | NORFOLK SHIPBUILDING & DRYDOCK | 4383 | VA | 0.63 | 1.50 | 2.22 | 0.32 | 1.50 |
| JAMES | NORFOLK SHIPBUILDING & DRYDOCK | 4391 | VA | 0.12 | 0.28 | 0.41 | 0.06 | 0.28 |
| JAMES | NORFOLK SHIPBUILDING & DRYDOCK | 4405 | VA | 0.11 | 0.25 | 0.38 | 0.05 | 0.25 |
| JAMES | PURITAN BENNET CORP | 3042 | VA | . | 0.06 | 0.63 | 0.13 | 0.00 |
| JAMES | RAMSEY & KELLEY INC | 56413 | VA | 0.00 | 0.07 | 0.01 | 0.03 | 0.13 |
| JAMES | REGIONAL ENTERPRISES INC | 56359 | VA | 0.00 | 0.01 | 0.00 | 0.00 | 0.62 |
| JAMES | REYNOLDS METAL COMPANY SOUTH P | 50156 | VA | 0.46 | 0.44 | 12.41 | 2.36 | 6.14 |
| JAMES | ROYSTER CO | 3174 | VA | 0.02 | 0.04 | 0.02 | 0.23 | 0.02 |
| JAMES | SHELLER GLOBE CORP | 4812 | VA | 0.00 | 0.00 | 0.00 | . | . |
| JAMES | THE J G WILSON CORP | 28878 | VA | . | 0.00 | 0.00 | 0.00 | . |
| JAMES | VEPCO CHESTERFIELD | 4146 | VA | . | 7.06 | 3.53 | 16.48 | . |
| JAMES | VIRGINIA ELECTRIC AND POWER CO | 55344 | VA | . | 0.00 | 0.00 | 0.60 | . |

(continued)

TABLE 6. (continued)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | METAL LOAD (LBS/DAY) CADMIUM | CHROMIUM | COPPER | LEAD | ZINC |
|---|---|---|---|---|---|---|---|---|
| PATUXEN | POTOMAC ELECTRIC POWER COMPANY | 54836 | MD | . | 0.13 | 0.06 | 0.29 | . |
| POTOMAC | MINERAL PIGMENTS CORP BLTVILLE | 3425 | MD | 0.00 | 1.80 | 0.00 | 0.08 | 1.59 |
| POTOMAC | PEPCO POTOMAC RIVER | 2488 | VA | . | 2.18 | 1.09 | 5.09 | . |
| POTOMAC | PEPCO CHALK POINT | 2658 | MD | . | 0.00 | 25.00 | 0.00 | . |
| POTOMAC | POTOMAC ELECTRIC POWER COMPANY | 56928 | MD | . | 0.00 | 0.00 | 0.00 | |
| POTOMAC | SOUTHERN MARYLAND WOOD TREATIN | 51799 | MD | 0.01 | 0.03 | 0.17 | 0.05 | 0.48 |
| POTOMAC | VEPCO POSSUM POINT | 2071 | VA | . | 2.00 | 1.00 | 4.66 | . |
| RAPP | ARROWHEAD ASSOCIATES INC. | 30198 | VA | 0.02 | 0.08 | 0.06 | 0.01 | 0.06 |
| W CHESAP | A Z BOGERT INC | 53872 | MD | . | 0.00 | 0.00 | 0.00 | |
| W CHESAP | A-1 PLATING CO | 54992 | MD | 0.01 | 0.06 | 0.02 | 0.00 | 1.20 |
| W CHESAP | ALLIED CHEM CORP-AGRIC DIV | 2526 | MD | . | 0.00 | 0.23 | 0.00 | 0.00 |
| W CHESAP | ALLIED CHEMICAL- BALTIMORE | 2186 | MD | 0.31 | 2.19 | 0.98 | 12.61 | 0.36 |
| W CHESAP | ALMAG CHEM BALTIMORE | 3417 | MD | 0.07 | 0.32 | 0.23 | 0.03 | 0.23 |
| W CHESAP | AMERICAN OIL CO BALTIMORE REF | 388 | MD | 0.00 | 0.09 | 0.07 | 0.03 | 0.16 |
| W CHESAP | AMERICAN RECOVERY CO | 1171 | MD | 0.02 | 0.44 | 0.08 | 0.17 | 0.81 |
| W CHESAP | AMOS JUDD & SON INC | 52655 | MD | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 |
| W CHESAP | ASARCO INC. | 493 | MD | 0.05 | 0.05 | 133.00 | 0.25 | 0.65 |
| W CHESAP | BATA SHOE CO INC BELCAMP | 1431 | MD | 0.00 | 0.00 | 0.00 | 0.00 | |
| W CHESAP | BELKO CORP.,THE | 54666 | MD | 0.00 | 0.00 | 0.00 | 0.00 | . |
| W CHESAP | BETHLEHEM STEEL CORP SPARROW P | 1201 | MD | 64.00 | 264.00 | 66.00 | 30.90 | 258.50 |
| W CHESAP | BETHLEHEM STEEL CORP SPARROWS | 1180 | MD | 0.02 | 0.03 | 0.53 | 0.41 | 0.64 |
| W CHESAP | BETHLEHEM STEEL-TANKER CLEAN. | 2275 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| W CHESAP | BG&E CALVERT CLIFFS | 2399 | MD | . | 0.00 | 90.18 | 0.00 | |
| W CHESAP | BG&E CRANE | 1511 | MD | . | 0.00 | 11.85 | 0.00 | . |
| W CHESAP | BG&E GOULD STREET | 1490 | MD | . | 0.00 | 5.35 | 0.00 | . |
| W CHESAP | CHEMETALS CORP | 1775 | MD | 0.03 | 0.23 | 0.11 | 1.35 | 0.04 |
| W CHESAP | CHESAPEAKE PARK INC | 2852 | MD | 0.01 | 0.02 | 0.02 | 0.00 | 0.02 |
| W CHESAP | CHEVRON U.S.A.INC. | 1449 | MD | 0.01 | 0.21 | 0.04 | 0.08 | 0.38 |
| W CHESAP | CONTINENTAL CAN CO INC 16 | 50750 | MD | 0.03 | 0.12 | 0.09 | 0.01 | 0.09 |
| W CHESAP | CONTINENTAL OIL BALTO PETRO PL | 540 | MD | 0.04 | 1.05 | 8.36 | 13.42 | 1.92 |
| W CHESAP | CROWN CORK & SEAL CO INC PT 10 | 116 | MD | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 |
| W CHESAP | DUTCH BOY,INC. | 1295 | MD | | | | 0.02 | |
| W CHESAP | FARBCIL CO.-DIV. BEATRICE FOOD | 51659 | MD | . | 0.00 | 0.00 | 0.00 | . |
| W CHESAP | FIRESTONE PLASTICS CO. FIRESTO | 56391 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| W CHESAP | FMC CORP INDUSTRIAL CHEM DIV | 299 | MD | 0.05 | 1.43 | 0.25 | 0.54 | 2.60 |
| W CHESAP | JS YOUNG COMPANY-BALTIMORE | 1066 | MD | 0.00 | 0.02 | 0.00 | 0.01 | 0.03 |
| W CHESAP | KAISER ALUMINUM HALETHORPE WKS | 477 | MD | 0.91 | 0.88 | 24.55 | 4.68 | 12.16 |
| W CHESAP | KAISER ALUMINUM USAF | 485 | MD | 0.04 | 0.56 | | 0.05 | |
| W CHESAP | KENNECOTT REFINING CORP BALTO | 507 | MD | 0.55 | 0.53 | 1.55 | 2.84 | 35.00 |
| W CHESAP | KEYSTONE AUTOMOTIVE PLATING | 25046 | MD | 0.04 | 0.17 | 0.13 | 0.02 | 0.13 |
| W CHESAP | KOPPERS CO INC BALT PLANT | 1228 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |

(continued)

TABLE 6. (continued)

| MAJOR BASIN | FACILITY NAME | NPDES NUMBER | STATE | METAL LOAD (LBS/DAY) CADMIUM | CHROMIUM | COPPER | LEAD | ZINC |
|---|---|---|---|---|---|---|---|---|
| W CHESAP | KOPPERS CO INC-METAL PROD DIV | 1911 | MD | 0.21 | 5.40 | 0.73 | 0.10 | 0.73 |
| W CHESAP | MARYLAND STEEL DRUM COMPANY | 54976 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| W CHESAP | MD SHIPBLDG&DRYDOCK CO CORP | 1392 | MD | 0.01 | 0.02 | 0.03 | 0.00 | 0.02 |
| W CHESAP | SCM CORP PENCO PLANT (HOBAY) | 1252 | MD | 0.16 | 1.65 | 0.05 | 16.40 | 0.20 |
| W CHESAP | SCM CORP-ADRIAN JOYCE WORKS | 1261 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| W CHESAP | SCM CORP-ST HELENA PLANT | 1279 | MD | 0.04 | 0.29 | 0.13 | 1.67 | 0.05 |
| W CHESAP | SECURITY PLATING CO | 55042 | MD | 0.05 | 0.12 | 0.18 | 0.01 | 3.40 |
| W CHESAP | SINCLAIR & VALENTINE CO INC | 51454 | MD |  | 0.00 | 0.00 | 0.00 |  |
| W CHESAP | UNION CARBIDE BALTIMORE PLANT | 124 | MD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| W CHESAP | UNION CARBIDE CORPORATION LIND | 54101 | MD | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| W CHESAP | WR GRACE DAVISON CHEM DIV | 111 | MD | 0.54 | 3.90 | 0.88 | 22.54 | 0.65 |
| YORK | AMOCO OIL CO | 3018 | VA | 0.17 | 4.89 | 0.89 | 1.89 | 8.89 |
| YORK | L A CLARK & SON INC | 5398 | VA | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 |

## SECTION 7

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# APPENDIX E

# EXISTING CONTROL PROGRAMS

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## SECTION 1

# FEDERAL CONTROL PROGRAMS

Major revisions were made during the 1970's to Federal legislation and administrative procedures applicable to water use and pollution control. Enactment of the National Environmental Policy Act, the 1972 Federal Water Pollution Control Act (FWPCA), the Coastal Zone Management Act, the Marine Protection Research and Sanctuaries Act, and other legislation fundamentally altered national policy and the traditional division of resource management responsibilities between the Federal and state governments.

The Council on Environmental Quality (CEQ) and the Environmental Protection Agency (EPA) were established, in part, to consolidate administrative oversight and resource protection responsibilities within the Federal government. Authorization for the CEQ and the EPA also established Congress' intent to clarify responsibility for environmental protection through implementation of new, uniform, technology-based performance standards applicable to all industrial and municipal discharges, regardless of location.

Since 1972, the EPA has had responsibility for regulating municipal and industrial activities that pollute or alter the quality of water resources. The FWPCA (PL92-500) and the 1977 Clean Water Act Amendments (CWA; PL95-217) raised the level of Federal funding for construction of publicly-owned waste treatment works (POTWs), elevated water quality planning especially for nonpoint source control, to a new level of significance; emphasized public participation in the water management decision-making process; and created the regulatory mechanism requiring uniform, technology-based effluent limitations, or more stringent limitations if required, to meet state water quality standards. As a means of enforcement, the FWPCA established a national permit system for use in regulating all municipal and industrial discharges.

Congress established mandatory treatment requirements to be met by all industries and municipalities within specific time frames. In addition, a national clean water objective, the restoration and maintenance of the chemical, physical, and biological integrity of the nation's waters was established, and water pollution control goals and policies were identified.

The goals established by the 1972 FWPCA are:

- to reach, "wherever attainable," a water quality that "provides for the protection and propagation of fish, shellfish, and wildlife" and "for recreation in and on the water" by July 1, 1983; and,
- to eliminate the discharge of pollutants into navigable waters by 1985.

The policies are:

- to prohibit the discharge of toxic pollutants in toxic amounts;

- to provide Federal financial assistance for construction of publicly-owned treatment works;
- to develop and implement area-wide waste treatment management planning which addresses both point and nonpoint source pollution;
- to mount a major research and demonstration effort in wastewater control and treatment technology; and
- to recognize, preserve, and protect the primary responsibilities and roles of the states to prevent, reduce, and eliminate pollution.

These goals and policies remain in effect today. In addition, the 1977 CWA expanded the role of the states by providing for management delegation of the National Pollutant Discharge Elimination System permit program (NPDES) and the POTW construction grants program, both described below. Congress also up-graded programs authorizing Federal financial support for state pollution control programs and emphasized the need for cooperative efforts among all levels of government so that comprehensive pollution control solutions could be put in place.

Currently, the EPA and individual states establish management priorities and pollution control objectives annually during the state-EPA agreement negotiation process. These agreements cover all delegated program activities, identify how states will manage Federal pollution control grants, and establish how management responsibilities will be divided between the state and the EPA regional office. The regulatory basis and tasks in water pollution control established by the Clean Water Act are as follows:

- Industrial and Municipal Effluent Limitations

  Uniform, technology-based effluent limitations applicable to all industries and municipalities are developed by the EPA. Municipalities are required to meet secondary treatment standards, as defined by the EPA. Industrial control requirements depend on the chemical characteristics of effluent streams for particular industrial categories.

  The discharge of toxic pollutants in toxic amounts is prohibited. Conventional pollutant discharges and special nonconventional discharges are subject to the best technological controls available at reasonable costs. The EPA determines available control technologies and develops control guidelines which are used to develop effluent limitations for every discharge.

- The National Pollutant Discharge Elimination System (NPDES)

  All industrial and municipal discharges must obtain a NPDES permit. The EPA administers the NPDES, but states are authorized to assume responsibility for the program. The NPDES permits are issued every five years and are subject to immediate revision if the characteristics of a discharger's wastes change significantly. The NPDES permits establish the levels and types, of pollutants that can legally be discharged, specify monitoring and reporting requirements, and may list facility management practices ("Best Management Practices") and contingency plans designed to minimize runoff. Effluent limitations listed in the NPDES permit are expected to prevent a discharge from causing violations of state water quality standards.

- Water Quality Standards

  The EPA develops criteria for water quality that are used as guidance by the states in the development of water quality standards and stream-use designations.

  These criteria address total water quality -- chemical, physical, and biological characteristics, and the factors necessary for the protection and propagation of shellfish, fish, and wildlife. States, at least every three years, are required to review and adopt water quality standards for their waters. The EPA reviews the standards to ensure that criteria used by the states are at least as stringent as the Federal criteria. States have authority to adopt criteria more stringent than EPA's. A summary of water quality standards in the Chesapeake Bay basin is shown in Table 1.

- Dredge and Fill Permit Review

  The EPA, or delegated states, reviews permit applications for dredge or fill projects before the permits are approved by the Army Corps of Engineers. Conditions can be placed in permits to minimize environmental degradation. All dredge and fill proposals are regulated under the CWA permit program except normal farming, ranching, and silvaculture activities that do not cause permanent changes to a waterway.

- Water Quality Management Grants

  Numerous Federal grants are authorized by the CWA for use by state, local, and regional agencies in their water pollution control programs. The grants are subject to Congressional appropriation for specific categories of water pollution control activities, including research and development, construction of public wastewater treatment systems, area-wide water quality planning, training of pollution-control professionals, monitoring, and program support for state pollution control administrative agencies. The major grant categories administered by the EPA under the CWA are:

  - Area Wide Waste Treatment Management (Section 208) Grants

    The EPA is authorized to make grants to a state agency, regional agency, or qualified local planning agency for the development of area-wide waste treatment management plans, generally called 208 plans. The plans include an identification of existing point or nonpoint pollution sources and describe technological needs and institutional arrangements for eliminating or reducing pollutant loadings to waterways within the planning area. The Fish and Wildlife Service is required to assist planning agencies in the development of water quality management

TABLE 1. STATE WATER QUALITY STANDARDS -- CLASS DESIGNATION AND NUMERICAL CRITERIA

| Class | Description of waters | DO mg $L^{-1}$ min. | DO mg $L^{-1}$ daily av. | pH | max. °C | Fec. Col. Bact. max. MPN/100 ml | Turbidity NTU Max. | Turbidity NTU Mon. Avg. | Tot. Res. Max. Chlorine mg $L^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|
| VIRGINIA | | | | | | | | | |
| I | Open ocean | 5.0 | -- | 6.0-8.5 | -- | 200 | (Special standards set for some specific waters.) | | |
| II | Estuarine (Tidal water-coastal zone to fall line | | | | | | | | |
| III | Free flowing streams (coastal and Piedmont zones) | 4.0 | 5.0 | 6.0-8.5 | -- | 14 (in areas cap. of prop. shellfish) | | | |
| IV | Mountainous zone | 4.0 | 5.0 | 6.0-8.5 | 32 | 200 | (Special standards set for some specific waters.) | | |
| V | Put and take lake trout waters | 4.0 | 5.0 | 6.0-8.5 | 31 | 200 | | | |
| VI | Natural trout waters | 5.0 | 6.0 | 6.0-8.5 | 21 | 200 | (Special standards set for some specific waters.) | | |
| VII | Swamp water | 6.0 | 7.0 | 6.0-8.5 | 20 | 200 | | | |
| | | ( . . . case-by-case determinations will be made . . .) | | | | | " | " | |
| MARYLAND | | | | | | | | | |
| I | Water contact recreation and aquatic life | 5.0 | -- | 6.5-8.5 | 32 or ambient | 200 | 150 | 50 | -- |
| II | Shellfish harvesting | 5.0 | -- | 6.5-8.5 | 32 or ambient | 14 | 150 | 50 | -- |
| III | Natural trout waters | 5.0 | 6.0 | 6.5-8.5 | 20 or ambient | 200 | 150 | 50 | 0.002 |
| IV | Recreational trout waters | 5.0 | 6.0 | 6.5-8.5 | 23.9 or ambient | 200 | 150 | 50 | 0.002 |
| PENNSYLVANIA | | | | | | | | | |
| WWF | Warm water fishes | 4.0 | 5.0 | 6.0-9.0 | 87 °F | 200 | -- | -- | -- |
| TSF | Trout stocking | 4.0 | 5.0 | 6.0-9.0 | 87 °F | 200 | -- | -- | -- |
| | (Feb. 15 - July 31) | 5.0 | 6.0 | 6.0-9.0 | 74 °F | 200 | -- | -- | -- |
| DISTRICT OF COLUMBIA | | | | | | | | | |
| A | Primary contact recreation | | | 6.0-8.5 | | | | | |
| B | Secondary contact recreation | | | | | 200 | More than 20 NTU above ambient | | |
| C | Aquatic life and water | -- | -- | 6.0-8.5 | -- | 1000 | " | " | |
| | oriented wildlife | 5.0 | 4.0 | 6.5-8.5 | 32.2 | | | | |
| D | Raw water source for public water supply | -- | -- | 6.0-8.5 | -- | -- | More than 20 NTU above ambient | | 0.01 |
| E | Navigational use | -- | -- | 6.0-8.5 | -- | 1000 | " | " | |
| | | | | | | 1000 | " | " | |

Note: State-wide standards for toxic compounds and nutrients are limited. Only Pennsylvania has a state-wide nutrient standard of max 10 mg $L^{-1}$ nitrite plus nitrate as nitrogen. However, in all three states and the District of Columbia there are some nutrient and toxic compound standards under certain conditions in specific waters (see state-wide lists).

plans. The Department of Agriculture, acting through the Soil Conservation Service, is authorized to enter into agricultural cost-sharing agreements with farmers that adopt nonpoint pollution control measures recommended in area-wide water quality management plans. Comprehensive area-wide waste treatment management plans must be approved by a state's governor and be consistent with river basin plans (Section 303e plans), also developed by the state.

- State Administrative Grants

  General program support grants are used to monitor water quality, classify waters, and inventory point and nonpoint sources of pollution. States are required to report biannually on progress in meeting clean water objectives.

- Grants for Construction of POTWs

  The CWA authorizes annual appropriations to be divided among the states and used for planning, design, and construction of municipal sewage treatment systems. More than 30 billion dollars have been appropriated for POTW construction since 1972. Broad categories of municipal sewage treatment needs are eligible for Federal financial assistance, including construction of basic treatment facilities, collection systems, interceptor sewers, and on-site or decentralized treatment systems. The Federal government provides up to 75 percent of design and construction costs for conventional local sewage treatment systems. Up to 85 percent of costs are paid by the Federal government for "alternative" or "innovative" treatment systems. The Farmers Home Administration and Economic Development Administration also provide grants and loans for wastewater treatment system construction.

- Construction Management Assistance Grants

  States that assume responsibility for managing the municipal wastewater treatment construction grants program are eligible for management assistance grants. The management assistance grants are used for day-to-day program operations, including project design reviews and establishment of construction priorities within the state.

Other Federal agencies have legislative responsibilities for wildlife protection, water development, and Federal land management (Department of Interior); approval of state coastal zone management programs and marine fisheries management plans (National Oceanic and Atmospheric Administration); and oil and hazardous material coastal spill response (Department of Transportation -- Coast Guard).

The EPA also administers other programs designed to protect and enhance the quality of environmental resources. Land-based disposal of hazardous and conventional wastes are regulated under the Resource Conservation and Recovery Act. Ocean disposal of wastes are regulated under the Marine Protection Research and Sanctuaries Act. The Safe Drinking Water Act is

# U.S. ENVIRONMENTAL PROTECTION AGENCY

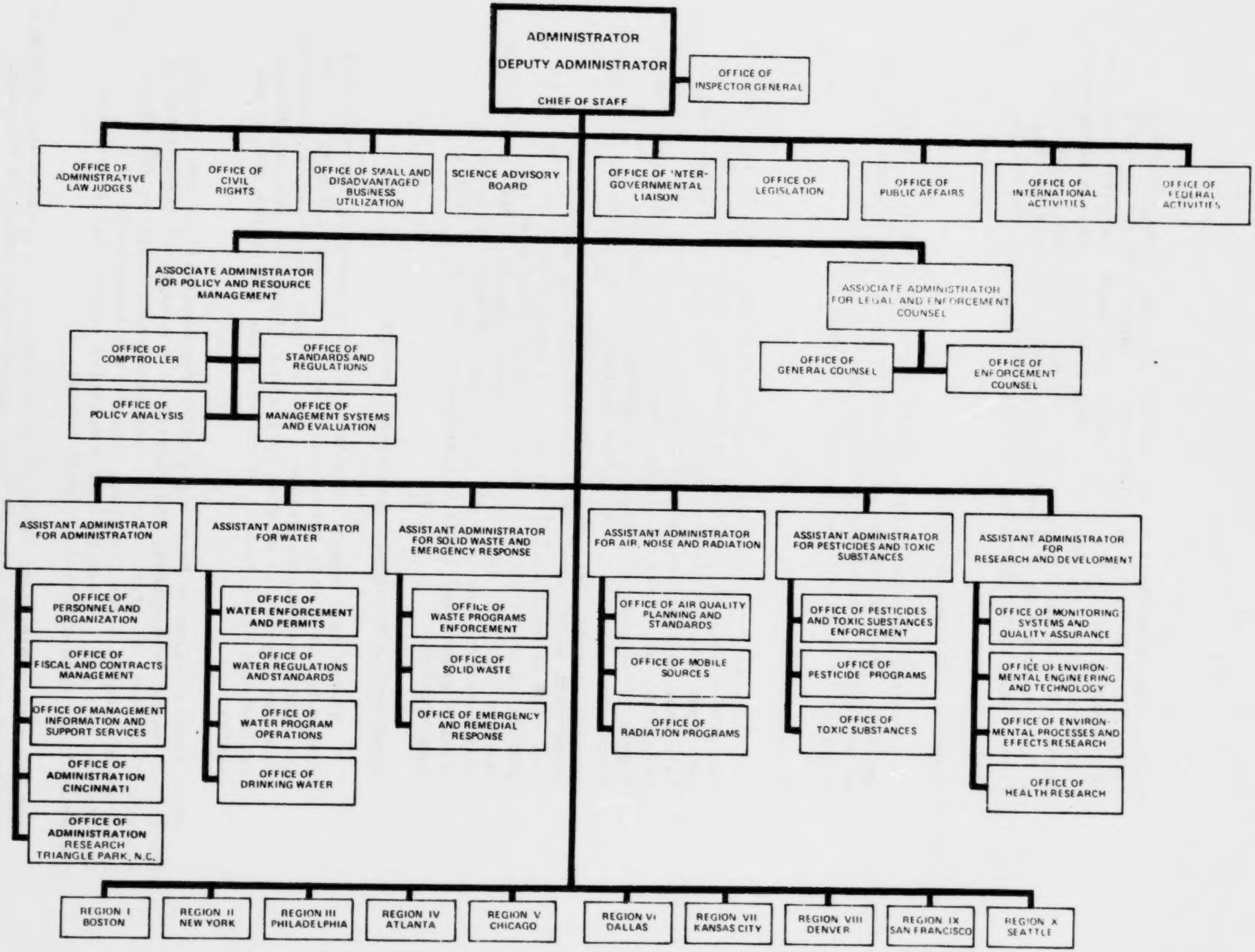

ADMINISTRATOR
DEPUTY ADMINISTRATOR
CHIEF OF STAFF
OFFICE OF INSPECTOR GENERAL
OFFICE OF ADMINISTRATIVE LAW JUDGES
OFFICE OF CIVIL RIGHTS
OFFICE OF SMALL AND DISADVANTAGED BUSINESS UTILIZATION
SCIENCE ADVISORY BOARD
OFFICE OF INTER-GOVERNMENTAL LIAISON
OFFICE OF LEGISLATION
OFFICE OF PUBLIC AFFAIRS
OFFICE OF INTERNATIONAL ACTIVITIES
OFFICE OF FEDERAL ACTIVITIES
ASSOCIATE ADMINISTRATOR FOR POLICY AND RESOURCE MANAGEMENT
OFFICE OF COMPTROLLER
OFFICE OF STANDARDS AND REGULATIONS
OFFICE OF POLICY ANALYSIS
OFFICE OF MANAGEMENT SYSTEMS AND EVALUATION
ASSOCIATE ADMINISTRATOR FOR LEGAL AND ENFORCEMENT COUNSEL
OFFICE OF GENERAL COUNSEL
OFFICE OF ENFORCEMENT COUNSEL
ASSISTANT ADMINISTRATOR FOR ADMINISTRATION
OFFICE OF PERSONNEL AND ORGANIZATION
OFFICE OF FISCAL AND CONTRACTS MANAGEMENT
OFFICE OF MANAGEMENT INFORMATION AND SUPPORT SERVICES
OFFICE OF ADMINISTRATION CINCINNATI
OFFICE OF ADMINISTRATION RESEARCH TRIANGLE PARK, N.C.
ASSISTANT ADMINISTRATOR FOR WATER
OFFICE OF WATER ENFORCEMENT AND PERMITS
OFFICE OF WATER REGULATIONS AND STANDARDS
OFFICE OF WATER PROGRAM OPERATIONS
OFFICE OF DRINKING WATER
ASSISTANT ADMINISTRATOR FOR SOLID WASTE AND EMERGENCY RESPONSE
OFFICE OF WASTE PROGRAMS ENFORCEMENT
OFFICE OF SOLID WASTE
OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
ASSISTANT ADMINISTRATOR FOR AIR, NOISE AND RADIATION
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
OFFICE OF MOBILE SOURCES
OFFICE OF RADIATION PROGRAMS
ASSISTANT ADMINISTRATOR FOR PESTICIDES AND TOXIC SUBSTANCES
OFFICE OF PESTICIDES AND TOXIC SUBSTANCES ENFORCEMENT
OFFICE OF PESTICIDE PROGRAMS
OFFICE OF TOXIC SUBSTANCES
ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
OFFICE OF MONITORING SYSTEMS AND QUALITY ASSURANCE
OFFICE OF ENVIRONMENTAL ENGINEERING AND TECHNOLOGY
OFFICE OF ENVIRONMENTAL PROCESSES AND EFFECTS RESEARCH
OFFICE OF HEALTH RESEARCH
REGION I BOSTON
REGION II NEW YORK
REGION III PHILADELPHIA
REGION IV ATLANTA
REGION V CHICAGO
REGION VI DALLAS
REGION VII KANSAS CITY
REGION VIII DENVER
REGION IX SAN FRANCISCO
REGION X SEATTLE

Figure 1. U.S. Environmental Protection Agency organizational chart

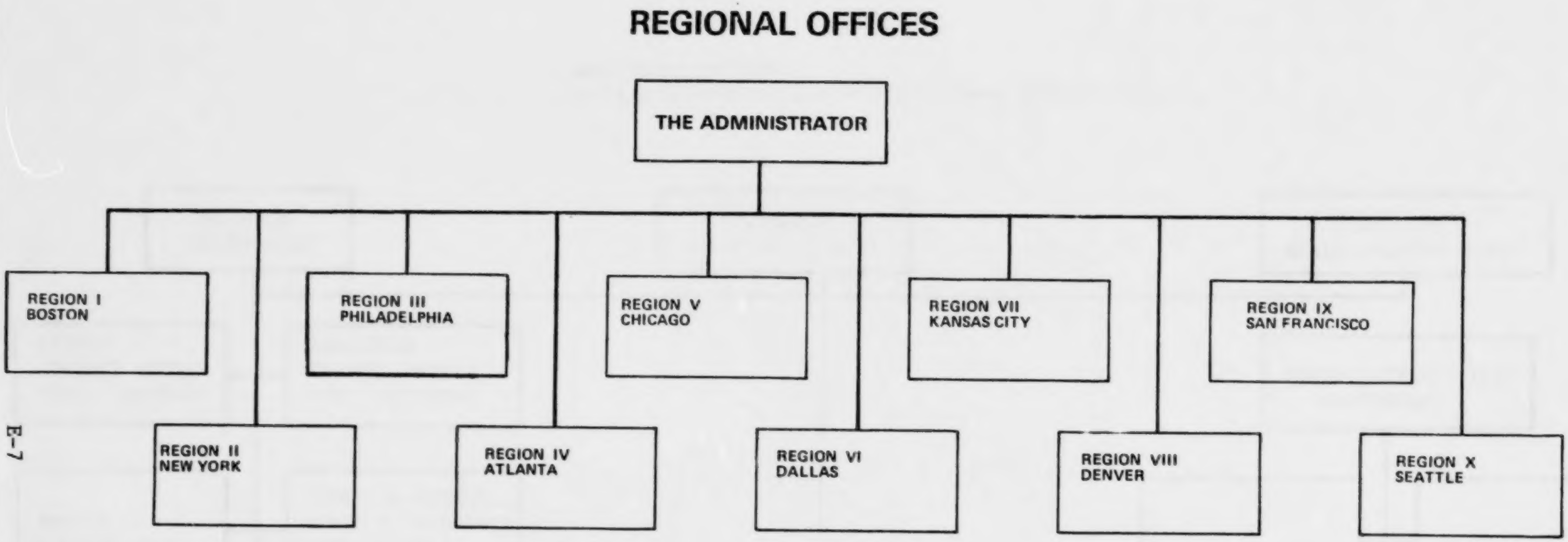

REGIONAL OFFICES

Figure 2. U.S. Environmental Protection Agency regional offices

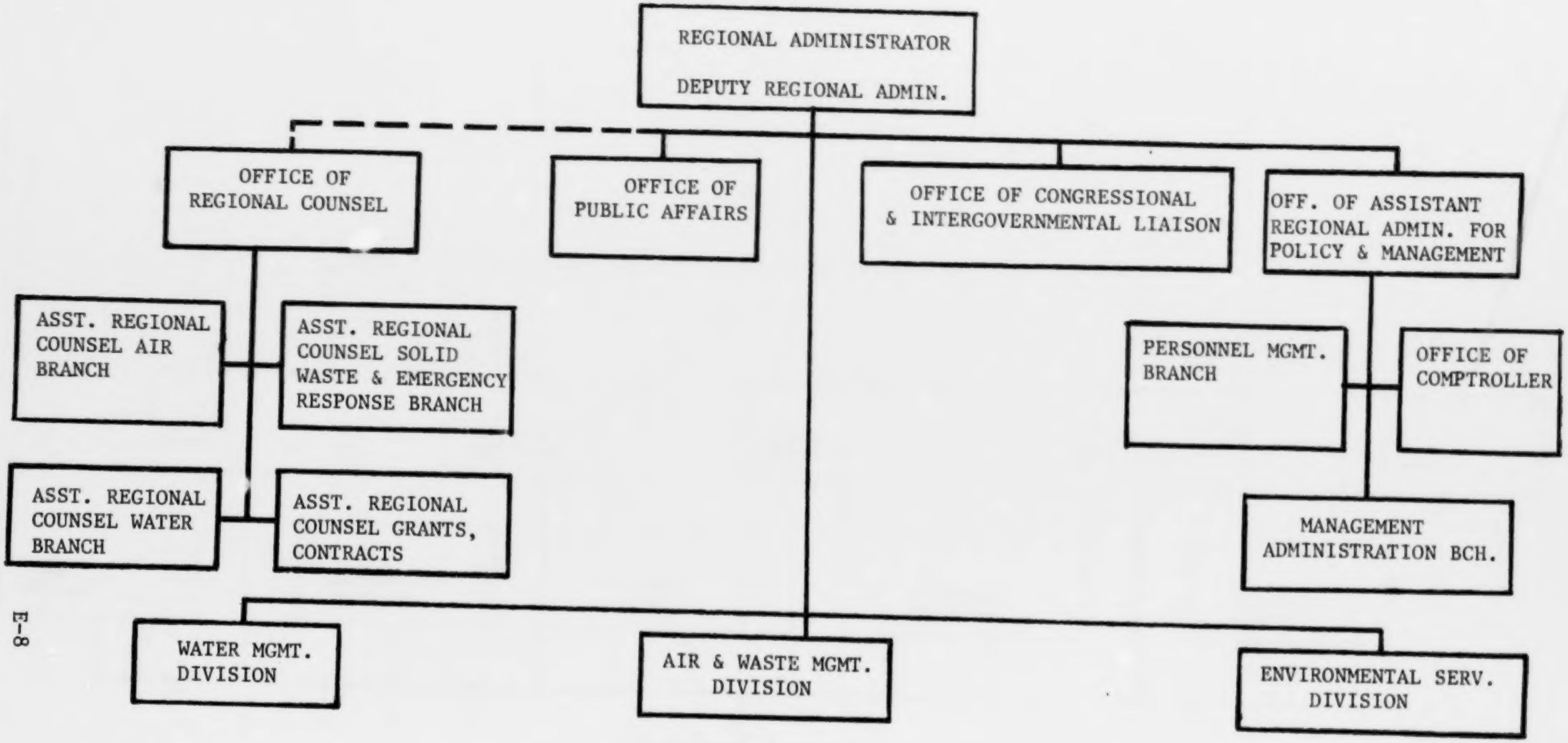

REGIONAL ADMINISTRATOR
DEPUTY REGIONAL ADMIN.
OFFICE OF REGIONAL COUNSEL
OFFICE OF PUBLIC AFFAIRS
OFFICE OF CONGRESSIONAL & INTERGOVERNMENTAL LIAISON
OFF. OF ASSISTANT REGIONAL ADMIN. FOR POLICY & MANAGEMENT
ASST. REGIONAL COUNSEL AIR BRANCH
ASST. REGIONAL COUNSEL SOLID WASTE & EMERGENCY RESPONSE BRANCH
ASST. REGIONAL COUNSEL WATER BRANCH
ASST. REGIONAL COUNSEL GRANTS, CONTRACTS
PERSONNEL MGMT. BRANCH
OFFICE OF COMPTROLLER
MANAGEMENT ADMINISTRATION BCH.
WATER MGMT. DIVISION
AIR & WASTE MGMT. DIVISION
ENVIRONMENTAL SERV. DIVISION

Figure 3. U.S. Environmental Protection Agency Region III organizational chart

used to establish quality standards for potable water, prescribe treatment techniques, establish monitoring and performance standards for sub-surface disposal of wastes, and approve aquifer protection petitions. The Comprehensive Environmental Response, Compensation and Liability Act establishes a fund for the clean-up of abandoned hazardous waste sites. The Clean Air Act is used to regulate air emmissions and enforce state clean air implementation plans. All EPA programs are managed according to policy guidelines established by the agency Administrator in Washington. Within the headquarters offices, major program priorities are identified by Assistant Administrators responsible for specific legislative mandates (see Figure 1 for current headquarters organizational chart). Although policies and program priorities are established in EPA's Washington offices, program management is accomplished by Regional Administrators located in 10 cities throughout the continental United States. In addition to "line management" responsibilities, the 10 regional administrators are authorized to negotiate environmental management, delegation, and other administrative agreements involving the use of Federal environmental protection funds with individual states. The three states involved in management of the Chesapeake Bay are located in EPA's Region III. The Regional Offices are in Philadelphia, Pennsylvania (see Figures 2 and 3 for regional organization).

As mentioned previously, the EPA administers a variety of legislation, all of which is focused primarily on the protection or enhancement of the environment. Although there are several national programs authorized by Congress involving Federal management of land usage, Federal jurisdiction is limited to management of lands owned by the U.S. government. There currently are no Federal laws authorizing general Federal land management programs.

The CBP has produced a directory of Federal, state, and local agencies that administer programs which directly affect Chesapeake Bay environmental quality. The following Federal agencies also are involved to some extent in environmental management, as defined and limited by specific legislative authorization:

o Council on Environmental Quality (CEQ)

The passage of the National Environmental Policy Act (NEPA) has resulted in a dramatic modification of all Federal agency responsibilities, for the act mandated a comprehensive environmental review of all major Federal actions significantly affecting the human environment. This review was to take place early enough in the agency decision-making process to influence the outcome of Federal agency deliberations. However, this is not the only Federal environmental review statute. Some thirty other Federal statutes impose environmental requirements on Federal activities. Traditionally mission-oriented agencies can no longer manage their area of concern by their own professioal standards. They must satisfy air and water quality standards, be aware of how state coastal zone management plans affect their mission, take account of the Corps of Engineers requirements for wetlands and water course areas, identify endangered species and their habitats, and prepare environmental impact statements for all major Federal actions.

The National Environmental Policy Act of 1969 was designed to incorporate environmental considerations into Federal agency decision-making. The basic idea was to require agencies to explore, consider, and publicly describe the adverse effects of their programs. The assumption was that those programs would be revised in favor of less environmentally damaging activities. The vehicle for achieving this was the "action-forcing" provision of NEPA which requires the preparation of an Environmental Impact Statement (EIS) on every major Federal action significantly affecting the human environment. The CEQ reviews the EIS and generally is responsible for coordinations of Federal activities.

- Coastal Zone Management Act (CZMA)

The CZMA was enacted in 1972 to encourage state governments to develop and implement land and water resource management programs for their coastal areas. The objective of these programs is to establish comprehensive and coordinated management to assure the orderly and environmentally sound development of coastal areas. The Federal government provides financial assistance to the states to develop and implement these programs if the states meet the guidelines established for program approval. These guidelines are rather broad and basically require the state to establish a process for making decisions on coastal resource use, rather than requiring any specific substantive decisions.

Once a state has an approved program, all Federal, Federally-assisted, or licensed projects must be certified as consistent with the state program before they can go forward. Although this looks like a potentially powerful mechanism for state governments to control Federal action, several exceptions can be made from the consistency requirement. If the project or license is necessary in the interest of national security, consistency will not apply. The Secretary of Commerce also can override a finding of "inconsistency" if the proposed action meets the broad objectives of the CZMA, satisfies requirements of the Clean Air Act and the FWPCA, the adverse impacts are outweighed by the benefits to the nation, and there is no reasonable alternative to the action.

- Fish and Wildlife Coordination Act (FWCA)

One of the oldest environmental review statutes is the Fish and Wildlife Coordination Act. It has had a substantial impact on the planning and development of certain types of Federal projects, particularly Army Corps of Engineers (COE) dam projects. It applies to Federal licenses and permits and basically to any Federal agency activities that would affect the water of the United States. The agency preparing the action must consult with the Fish and Wildlife Service (FWS) concerning the conservation of wildlife.

- The Endangered Species Act (ESA)

The ESA is a recent addition to the area of environmental review statutes. The key provision is Section 7, which requires all Federal agencies to ensure that their activities do not jeopardize the continued existence of endangered or threatened species and their habitats. The administration of this law is divided between the FWS and the National Marine Fisheries Service (NMFS), with NMFS being responsible for marine species.

- Marine Protection Research and Sanctuaries Act (MPRSA)

The MPRSA authorizes the Department of Commerce to designate various areas as marine sanctuaries. These areas must be of important conservation, recreation, ecological, or aesthetic value in ocean, estuarine, or Great Lakes waters. Designated sanctuaries are to fall within one or a combination of five different classifications: habitat areas, species areas, research areas, recreational and aesthetic areas, and unique areas.

Before a sanctuary is designated, the Secretary of Commerce is required to consult with various Federal agencies, including the Secretary of Interior. However, these other agency viewpoints are not binding on Commerce. Once designated, Commerce has the authority to veto any Federal permits or licenses that would adversely affect the sanctuary. The MPRSA also contains a ban on ocean disposal of hazardous wastes which will degrade the marine environment. The EPA administers the ocean dumping provisions through issuance of permits for certain types of ocean dumping activities.

- The National Historic Preservation Act (NHPA)

This act established the National Register of Historic Places and requires Federal agencies to consult with the newly created Advisory Council on Historic Preservation whenever Federal projects could have adverse impacts on historic or archaeological sites. This would apply not only to sites that are on the register but also to those that are eligible for listing

- The Outer Continental Shelf Lands Act (OCSLA)

The purpose of the OCSLA is to regulate the granting of mineral leases on the OCS by the Federal government.

- The U.S. Department of Agriculture (USDA)

The USDA has been engaged in erosion-prevention efforts since the 1930's through local soil conservation districts, the U.S. Soil Conservation Service, and others to reduce the problem. These programs, originally intended primarily for soil conservation, now serve as the basis for water quality protection efforts in agricultural areas.

The Soil Conservation Service (SCS), as a branch of the USDA, provides District Conservationists and other Federal employers who work side-by-side with state and local officials. They provide outreach and technical assistance to farmers for pollution control, which includes the design of site-specific pollution control measures. The SCS produces many of the basic handbooks and specifications used by state conservation districts in their day-to-day work of farm plan development and sediment and erosion control plan review. In addition, the SCS performs research and development in pollution-control technology and carries out watershed management and other special studies. The SCS provides national inventory and monitoring studies as a resource base on a regular basis.

Another branch of the USDA is the Agricultural Stabilization and Conservation Service (ASCS). Through its national and state Agricultural Conservation Program, the ASCS provides cost-share opportunities and financial incentives to farmers initiating practices covered by the program.

## TABLE 2. SUMMARY OF EXISTING STATE WATER QUALITY CONTROL AND RESOURCE MANAGEMENT ACTIVITIES AFFECTING THE CHESAPEAKE BAY

---

### A. NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

| | |
|---|---|
| District of Columbia: | Administered by the Department of Environmental Services (Bureau of Air and Water Quality) |
| Maryland: | Administered by the Office of Environmental Programs, Department of Health and Mental Hygiene (Water Management Administration for municipal discharges, and Waste Management Administration for industrial discharges) |
| Pennsylvania: | Administered by the Department of Environmental Resources (Bureau of Water Quality Mangement) |
| Virginia: | Administered by the State Water Control Board |

All discrete (point source) discharges are regulated under the NPDES, which has been delegated by EPA to each of these states. Included are industrial waste treatment facilities, and publicly and privately owned sewage treatment works. Dischargers must use Best Practicable Treatment Technology, be consistent with Area-wide Water Quality Management ("208") Plans, and meet State Water Quality Standards (see Table 1).

Special effluent limitations on phosphorus or nitrogen discharges have been set by each state for particular areas of the Bay or its tributaries as follows:

District of Columbia: No phosphorus or nitrogen limitation policy. Blue Plains Wastewater Treatment Plant NPDES Limits are:

| | Dates | 7-Day | 30-Day<br>-1 |
|---|---|---|---|
| | | mg/L | |
| Total Kjeldahl Nitrogen | 4/1-10/31 | 2.4 | 3.6 |
| | 11/1-3/31 | 5.0 | 7.5 |
| Total Phosphorus | | 0.22 | 0.33 |

Administered by the Department of Environmental Services (Bureau of Air and Water Quality)

(continued)

TABLE 2. (Continued)

| | |
|---|---|
| Maryland: | Upper Chesapeake Bay Phosphorus Policy: Effluent limit of 2.0 mg L -1 phosphorus for all waste-water treatment facilities discharging more than 0.5 MGD above the Gunpowder River and more than 10 MGD between the Gunpowder and Choptank Rivers. |
| Pennsylvania: | Pennsylvania Susquehanna River Discharge Policy: At least 80% removal of phosphorus by all new or modified waste-water treatment facilities to mainstem or tributaries below Juniata River. |
| Virginia: | Special water quality standards for nitrogen and phosphorus have been set by Virginia for tidal embayments of the Potomac River, in the Washington, DC area, the Chickahominy River, and the Lynnhaven River. |

B. CONSTRUCTION GRANTS FOR PUBLICLY OWNED SEWAGE TREATMENT WORKS

| | |
|---|---|
| District of Columbia: | Administered by the Department of Environmental Services (Bureau of Air and Water Quality) |
| Maryland: | Administered by the Office of Environmental Program Department of Health and Mental Hygiene (Water Management Administration) |
| Pennsylvania: | Administered by the Department of Environmental Res (Bureau of Water Quality Management) |
| Virginia: | Administered by the State Water Control Board |

The allocation of Federal Construction Grant Funds for planning, design, an construction of POTWs is managed by each of the states although final regulatory authority is held by EPA, Region III. POTWs must be consistent with Area-wide Water Quality Management ("208") Plans, and meet State Water Quality Standards (see Table 1) and special effluent limitations (see NPDES above) Priorities for the allocation of funds are set by each state, using the following general criteria:

(continued)

TABLE 2. (Continued)

---

**District of Columbia:**

1. Impairment of water uses from existing municipal discharges.
2. Extent of resulting improvements of surface and ground-water.
3. Completing system for a phase previously awarded.
4. Population served.
5. Specific category need addressed.

**Maryland:**

1. Needs category and purpose--type of facility improvements.
2. Stream segment severity--existing quality.
3. Project benefit--water quality and health.
4. Population affected.
5. Special program goals.

**Pennsylvania:**

1. Water pollution control factors.
2. Stream segment priority.
3. Population affected.

**Virginia:**

1. Public health impacts.
2. Severity of effect on water quality.
3. Population served.
4. Need to preserve existing high quality waters.

### C. SEDIMENT AND EROSION CONTROL

**District of Columbia:** Local program administered by Department of Consumer and Regulatory Affairs (Flooding and Erosion Control Section). Regulatory requirement applied to erodible material exposed by any project activity, with permits for all projects and plans for projects more than 50 sq. ft. and/or $2500.

**Maryland:** Responsibility of the Department of Natural Resources (Water Resources Administration). State law requires sediment and erosion control measures for all construction activities. Certain aspects of program are delegated to local jurisdictions, with state oversight.

(continued)

TABLE 2. (Continued)

| | |
|---|---|
| Pennsylvania: | Administered by the Department of Environmental Resources, Bureau of Soil and Water Conservation. Regulatory requirement for persons engaged in earth-moving activities to maintain control measures, with permits required for activities involving more than 25 acres. |
| Virginia: | Responsibility of Soil and Water Conservation Commission. Counties and cities must adopt and enforce state E. & S. Standards, or develop their own, which must be at least as restrictive as state standards. State provides oversight. |

D. AGRICULTURAL RUNOFF CONTROL

| | |
|---|---|
| District of Columbia: | Not applicable |
| Maryland: | State Agricultural Cost-Sharing Program (enacted in 1982) administered by the Department of Agriculture and Office of Environmental Programs, Department of Health and Mental Hygiene. Critical watersheds and appropriate practices needed identified in State-wide 208 Plan for Agricultural Runoff, administered by State Soil Conservation Committee. Soil Conservation districts promote development of voluntary soil conservation plans. |
| Pennsylvania: | State regulations require all farms to have conservation plans. In practice, however, program is voluntary. Conservation plan development for farms by Soil Conservation Districts. Best Management Practices for manure management identified by Department of Environmental Resources. Priority watersheds needing control identified in State Agriculture and Earthmoving ("208") Plan, administered by the Department of Environmental Resources. |
| Virginia: | Voluntary program of compliance with Best Management Practices developed by the State Water Control Board (SWCB). Soil Conservation Districts provide technical assistance. Priority watersheds needing control have been identified by the SWCB, Soil and Water Conservation Commission, and the US Department of Agriculture, Soil Conservation Service. |

(continued)

TABLE 2. (Continued)

E. URBAN RUNOFF CONTROL

| | |
|---|---|
| District of Columbia: | Local program administered by the Department of Environmental Services. Maintains street sweeping and catch-basin cleaning. |
| Maryland: | State-wide storm-water management law (aimed at both quantity and quality of runoff) enacted in 1982, administered by the Department of Nautral Resources, Water Resources Administration. Counties must enact stormwater management ordinances (by 7/84) that are at least as strict as state guidelines to be developed by 6/83. |
| Pennsylvania: | Storm water management program administered by the Department of Environmental Resources (Bureau of Dams and Waterway Management). Counties must prepare watershed plans. Localities must adopt implementing ordinances. Both plans and ordinances are to address quality as well as quantity of stormwater runoff. |
| Virginia: | State-wide voluntary program of compliance with Best Management Practices. Localities have option of requiring control. State-wide stormwater management law enacted in 1982 and is administered by the State Soil Conservation Commission. |

F. SHELLFISH SANITATION

| | |
|---|---|
| District of Columbia: | Not applicable |
| Maryland: | Responsibility of the Department of Health and Mental Hygiene (Water Management Administration). Establishes regulatory standards, monitors shellfish growing areas, and closes areas unsafe for the taking of shellfish. |
| Pennsylvania: | Not applicable |
| Virginia: | Responsibility of the Department of Health (Bureau of Shellfish Sanitation). Established regulatory standards, monitors shellfish growing areas, and closes areas unsafe for the taking of shellfish. |

(continued)

TABLE 2. (Continued

G. FISHERIES MANAGEMENT

| | |
|---|---|
| District of Columbia: | Local program development begun by the Department of Environmental Services (Bureau of Air and Water Quality) and Department of Recreation. |
| Maryland: | Department of Natural Resources (Tidewater Administration) regulates the taking of fish, licenses commercial and recreational fishermen, and coordinates an extensive oyster culture program. |
| Pennsylvania: | Fish Commission administers fishing and boating laws and is responsible for propagation and protection of fish life. |
| Virginia: | Marine Resources Commission manages public oyster grounds and leases state-owned bottom to private shellfish growers. Licenses commercial and recreational fishermen. |

H. WETLANDS MANAGEMENT

| | |
|---|---|
| District of Columbia: | Not applicable |
| Maryland: | Dredging and filling of public and private wetlands are regulated by the Department of Natural Resources (Water Resources Administration). |
| Pennsylvania: | Administered by the Department of Environmental Resources, Bureau of Dams and Waterways Management. |
| Virginia: | State Wetlands Act authorizes localities to establish local Wetlands Boards to regulate activities affecting wetlands. Oversight by Marine Resources Commission. |

I. DREDGING, FILLING, AND DREDGED MATERIAL PLACEMENT

| | |
|---|---|
| District of Columbia: | Administered by the Department of Environmental Services (Bureau of Air and Water Quality). While final authority is held by the Army Corps of Engineers, the District performs many of the program activities.* |

(continued)

---

*Enabling legislation for delegation is pending before the District of Columbia Corporation Council; passage by the City Council and signing by the Mayor is expected later in 1983.

TABLE 2. (Continued)

| | |
|---|---|
| Maryland: | (See Wetlands Management above.) The Department of Natural Resources jointly processes state wetlands permit applications and those required by the U.S. Army Corps of Engineers. Office of Environmental Programs, Department of Health and Mental Hygiene (Water Management Administration) issues Water Quality Certificates for these permits. |
| Pennsylvania: | Not applicable |
| Virginia: | Responsibility of the Marine Resources Commission, which jointly processes state permit applications and those required by the U.S. Army Corps of Engineers. The State Water Control Board issues Water Quality Certificates for these permits. |

Section 2

# STATE WATER QUALITY CONTROL PROGRAMS

## OVERVIEW

Maryland, Pennsylvania, Virginia, and the District of Columbia (DC) have established state programs to control discharges of pollutants and to protect and enhance the quality of their waters, including the Chesapeake Bay. These states also have fisheries and wetlands management programs, which are concerned indirectly with Chesapeake Bay water quality. Table 2 summarizes the major existing state programs. A more detailed discussion of Federal authorizing legislation and individual state programs can be found in Appendix B.

All three states and DC have been delegated authority by the EPA for administration of the National Pollution Discharge Elimination System. The primary difference among each state's program is the extent of treatment dischargers must provide to comply with individual state water quality standards. Standards are set by each state, and approved by the EPA. Each jurisdiction classifies its waters by use or by class, and each category has its own set of water quality standards. The use/class designations are different for each jurisdiction, with Virginia's being primarily related to the physical characteristics of the waters, and Maryland's being related to water uses. Pennsylvania's use/class designations are also related to anticipated water uses, but define a greater variety of uses (see Table 3).

All three states and the District also allocated Federal construction grants for publicly-owned sewage treatment works. Each jurisdiction allocates its funds according to a priority rating system, established by the state and approved by the EPA. The priority systems have been summarized in Table 2. Maryland gives approximately equal weight to pollution abatement, protection of water uses, type of facility improvement, and "special program goals". Pennsylvania's system is structured to support water-use objectives established by the state. Virginia sets priorities based on public health impacts, water quality conditions, population, and maintenance of existing high quality waters. The District's system ranks water-use protection and improvement of surface and ground water quality above completing the system for a phase previously awarded, the population to be served, and the specific category needed. Current state projects dealing with nonpoint source problems that are funded through EPA Region III's 208 program are included in Sectin 3 of this appendix along with maps showing problem areas.

All three states and DC have erosion and sediment control programs. Virginia's is delegated to local jurisdictions (where local jurisdictions do not assume responsibility, the state does); Maryland's is partly state, partly local; and Pennsylvania's is completely a state responsibility.

Agricultural runoff control is voluntary in all three states, although Pennsylvania regulations require farm conservation plans. In addition, all three states have worked with the Soil Conservation Service and identified

TABLE 3. STATE WATER QUALITY STANDARDS CLASS/USE DESIGNATIONS

| VIRGINIA | |
|---|---|
| I | Open Ocean |
| II | Estuarine (Tidal Water--Coastal Zone to Fall Line) |
| III | Free-Flowing Streams (Coastal Zone and Piedmont) |
| IV | Mountainous Zone |
| V | Put and Take Trout Waters |
| VI | Natural Trout Waters |
| VII | Swamp Water |

| MARYLAND | |
|---|---|
| I | Water Contact Recreation and Aquatic Life |
| II | Shellfish Harvesting |
| III | Natural Trout Waters |
| IV | Recreational Trout Waters |

| DISTRICT OF COLUMBIA | |
|---|---|
| A | Primary Contact Recreation |
| B | Secondary Contact Recreation |
| C | Aquatic Life and Water-Oriented Wildlife |
| D | Raw Water Source for Public Water Supply |
| E | Navigational Use |

| PENNSYLVANIA | |
|---|---|
| CWF | Cold-Water Fishes |
| WWF | Warm-Water Fishes |
| MF | Migratory Fishes |
| PWS | Potable Water Supply |
| IWS | Industrial Water Supply |
| LWS | Livestock Water Supply |
| AWS | Wildlife Water Supply |
| IRS | Irrigation |
| B | Boating |
| F | Fishing |
| WC | Water Contact Sports |
| E | Esthetics |
| HQ | High Quality Waters |
| EV | Exceptional Value Waters |
| N | Navigation |

watersheds with a high potential for agricultural pollution. These areas have been targeted for soil conservation funding. The USDA/EPA Rural Clean Water Program has funded grants to reduce agricultural runoff in three small watersheds, one in each state. The Maryland General Assembly passed a 5 million dollar cost-sharing program in 1982 for the implementation of agricultural runoff control practices.

Virginia has a voluntary program for urban runoff control. Pennsylvania and Virginia have enacted a mandatory stormwater management law that includes provisions for water quality, although funds have not been appropriated. The Maryland legislature has enacted a stormwater runoff law which the state is now beginning to implement. This law consists of enabling legislation which requires counties and municipalities to enact stormwater management ordinances by July 1, 1984. The state is developing regulations and guidance regarding requirements; this effort will be completed by July 1, 1983. The District of Columbia government administers a local program that includes street sweeping and catch basin cleaning. In addition to state efforts, regional water quality agencies (such as Baltimore's Regional Planning Council, Washington Council of

Governments, and Hampton Roads Water Quality Agency) are helping state and local governments develop solutions for stormwater runoff problems.

Virginia and Maryland have similar programs for shellfish sanitation and Bay fisheries management. Wetlands management is a local responsibility in Virginia and a state responsibility in Maryland. Dredging, filling, and dredged material placement programs are similar in Maryland, Virginia, and the District of Columbia. Shellfish and wetland programs in Pennsylvania are not applicable to the Bay.

## MARYLAND CONTROL PROGRAMS

Maryland's portion of the Chesapeake Bay encompasses the open Bay and its tributary estuaries which lie north of Smith Point at the mouth of the Potomac River. The Potomac River itself lies entirely in Maryland, except for its southern tributaries (the Virginia-Maryland boundary crosses from headland to headland) and the portion within the District of Columbia. Maryland's boundary with Virginia crosses the Bay from Smith Point through the middle of Pocomoke Sound on the Eastern Shore.

In Maryland, responsibility for water quality and water resource management is shared by the Office of Environmental Programs (OEP) in the Department of Health and Mental Hygiene, and the Department of Natural Resources (DNR). The Department of Transportation, the Department of State Planning, and the Department of Agriculture have limited responsibilities. From 1970 to 1980, the over-all authority and responsibility for planning, regulation, monitoring, and research affecting the water quality and ecology of the Maryland portion of the Chesapeake Bay resided in the Department of Natural Resources.

Maryland's environmental regulatory programs were reorganized in 1980, through a transfer of water quality and waste management programs from the Department of Natural Resources to the Department of Health and Mental Hygiene, where a new Office of Environmental Programs was created. As a result of the reorganization, the major programs which regulate water quality are administered by the Office of Environmental Programs; the Department of Natural Resources continues to administer the state water resources management programs. An organizational chart for the Office of Environmental Programs is shown in Figure 4, and for the Department of Natural Resources in Figure 5.

Two administrations in the Office of Environmental Programs are responsible for activities which affect and maintain Chesapeake Bay water quality. The Water Management Administration establishes water quality standards and approves county water and sewer plans, area-wide waste management ("208") plans, sewage treatment plant discharge permits, and construction grants for publicly-owned treatment works. The OEP also establishes standards for on-site sewerage and community water supplies. Water quality monitoring programs are administered by the Water Management Administration. The Waste Management Administration within OEP develops National Pollutant Discharge Elimination System permits for industrial facilities and administers permit programs for land disposal of hazardous and non-hazardous wastes. Each of the two OEP administrations is authorized to undertake facility inspections, compliance monitoring, and enforcement activities.

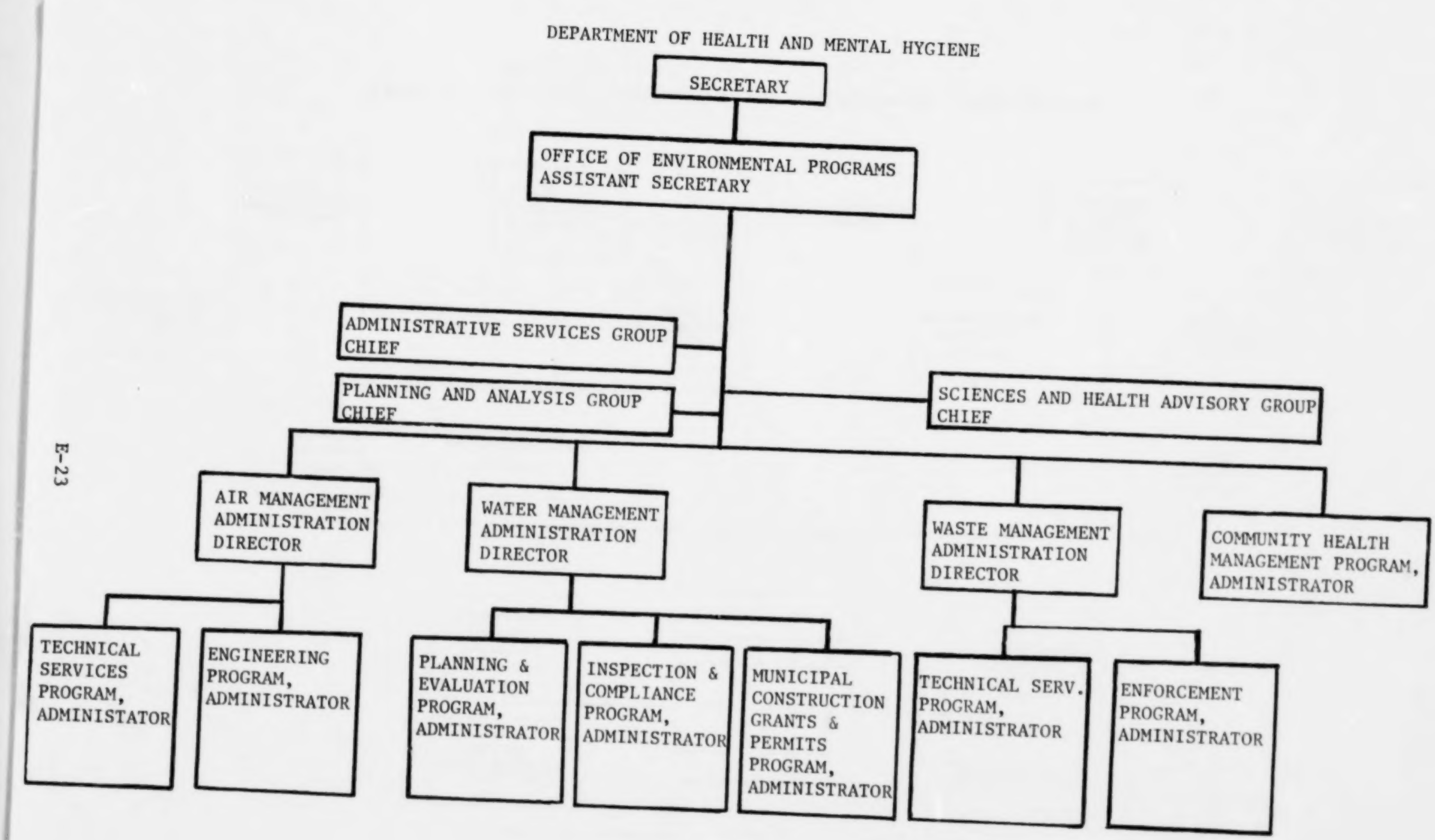

DEPARTMENT OF HEALTH AND MENTAL HYGIENE
SECRETARY
OFFICE OF ENVIRONMENTAL PROGRAMS ASSISTANT SECRETARY
ADMINISTRATIVE SERVICES GROUP CHIEF
PLANNING AND ANALYSIS GROUP CHIEF
SCIENCES AND HEALTH ADVISORY GROUP CHIEF
AIR MANAGEMENT ADMINISTRATION DIRECTOR
WATER MANAGEMENT ADMINISTRATION DIRECTOR
WASTE MANAGEMENT ADMINISTRATION DIRECTOR
COMMUNITY HEALTH MANAGEMENT PROGRAM, ADMINISTRATOR
TECHNICAL SERVICES PROGRAM, ADMINISTATOR
ENGINEERING PROGRAM, ADMINISTRATOR
PLANNING & EVALUATION PROGRAM, ADMINISTRATOR
INSPECTION & COMPLIANCE PROGRAM, ADMINISTRATOR
MUNICIPAL CONSTRUCTION GRANTS & PERMITS PROGRAM, ADMINISTRATOR
TECHNICAL SERV. PROGRAM, ADMINISTRATOR
ENFORCEMENT PROGRAM, ADMINISTRATOR

Figure 4. Maryland Office of Environmental Programs organizational chart

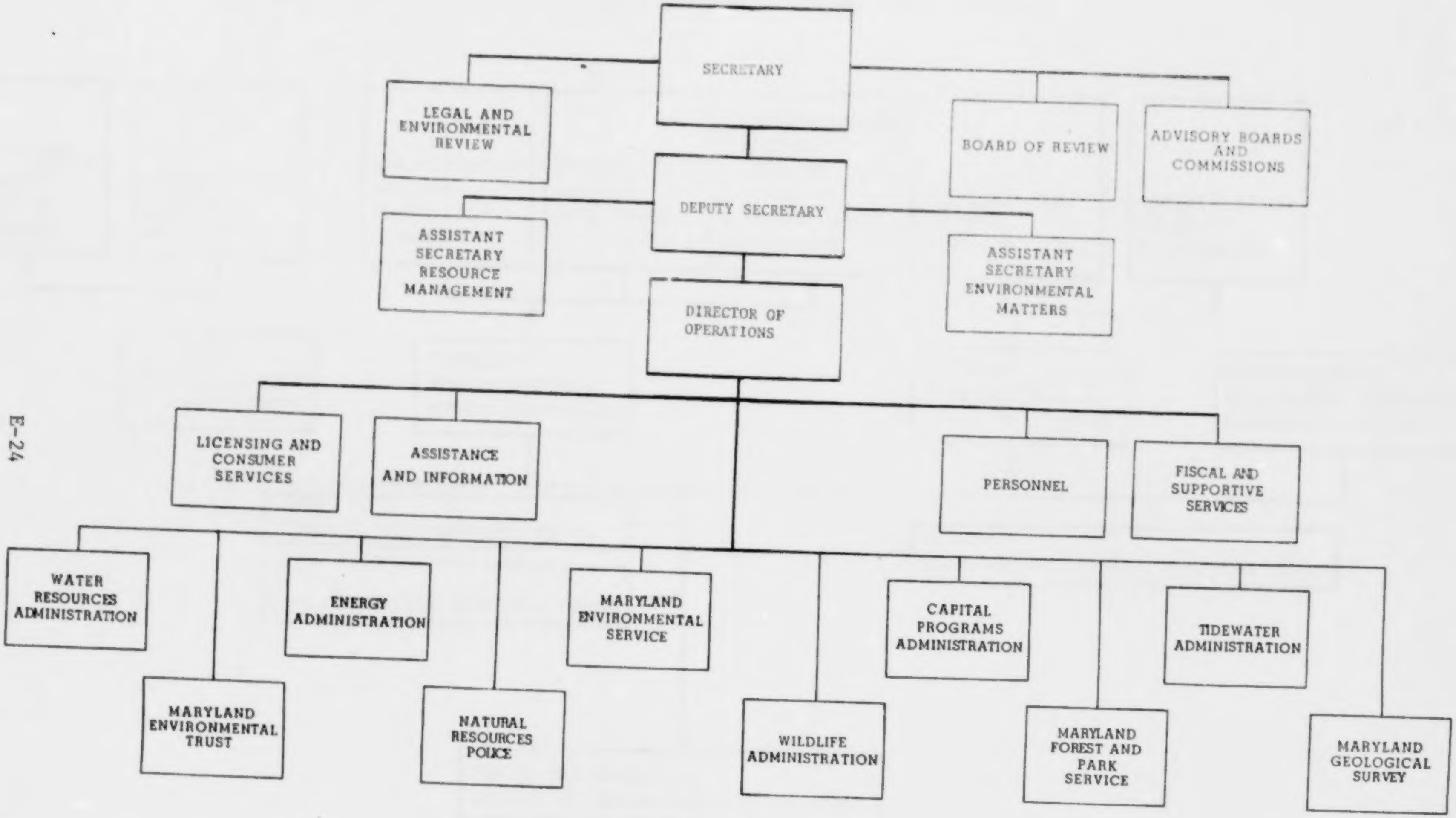

SECRETARY
LEGAL AND ENVIRONMENTAL REVIEW
BOARD OF REVIEW
ADVISORY BOARDS AND COMMISSIONS
DEPUTY SECRETARY
ASSISTANT SECRETARY RESOURCE MANAGEMENT
ASSISTANT SECRETARY ENVIRONMENTAL MATTERS
DIRECTOR OF OPERATIONS
LICENSING AND CONSUMER SERVICES
ASSISTANCE AND INFORMATION
PERSONNEL
FISCAL AND SUPPORTIVE SERVICES
WATER RESOURCES ADMINISTRATION
MARYLAND ENVIRONMENTAL TRUST
ENERGY ADMINISTRATION
NATURAL RESOURCES POLICE
MARYLAND ENVIRONMENTAL SERVICE
WILDLIFE ADMINISTRATION
CAPITAL PROGRAMS ADMINISTRATION
MARYLAND FOREST AND PARK SERVICE
TIDEWATER ADMINISTRATION
MARYLAND GEOLOGICAL SURVEY

Figure 5. Maryland Department of Natural Resources organizational chart

Several administrations in the Department of Natural Resources manage various aspects of Chesapeake Bay resources, including fisheries, wetlands, wildlife, erosion and sediment control, and emergency response to spills of oil.

The Water Resources Administration (WRA) includes regulatory programs applicable to activities affecting water quality such as sediment control, surface mining, small ponds, flood control, waterway construction and obstruction, dam safety, dredging and filling of private wetlands, and stormwater management. The WRA is also responsible for oil control. The WRA conducts water supply planning and issues water appropriations permits.

The Tidewater Administration of the DNR is responsible for several programs which are applicable to the tidal waters and adjacent areas, including coastal resources management (including the Federal Coastal Zone Management Program), enhancement of tidal fisheries, and improvement of navigable waterways through specific projects.

The DNR's Wildlife Administration regulates hunting and manages wildlife populations and habitats.

The Wetlands Administration regulates and develops permits for the dredging and filling of state-owned wetlands.

The DNR is primarily a regulatory and resource management agency. It also includes the Maryland Environmental Service, however, which constructs and operates wastewater treatment plants and potable water treatment and supply facilities.

Several other state agencies administer programs which affect the Chesapeake Bay. The Department of Natural Resources runs the Power Plant Siting Program, the Department of Transportation includes the Port Administration, and the Department of Agriculture regulates pesticides and participates in the planning of controls for agricultural sources of pollution.

The programs mentioned above were developed in response to state and Federal legislation as well as public concern. In addition to these programs, there are several state-mandated programs that are administered at the local level. Sediment and flood control, for example, are activities managed by local government agencies in accordance with state standards.

## Water Quality Management Activities

The following discussion is organized around the types of activities and facilities which may cause or alleviate water quality problems in the Chesapeake Bay. Each section briefly mentions the responsibilities and programs of the various governmental units concerned with the specific problem.

### Water Quality Standards--

The state's water quality standards are set and updated by the Water Management Administration, OEP. The standards are set by stream segment, and define the designated uses of the waters and the water quality criteria set to protect those uses. The water quality criteria used include coliform, dissolved oxygen, temperature, pH, turbidity, toxicants, and residual chlorine. The four water-use classes established for Maryland are: Class I -- Water Contact Recreation and Aquatic Life; Class II -- Shellfish Harvesting Waters; Class III -- Natural Trout Waters; and Class IV -- Recreational Trout Waters.

Effluent limitations are established in NPDES permits for all discharges which, according to guidance and engineering judgement, are designed to ensure compliance with existing water quality standards. In the upper Chesapeake Bay, an effluent limit of 2.0 mg $L^{-1}$ of phosphorus exists for all sewage treatment plants discharging more than 0.5 million gallons per day (MGD) north of Baltimore or discharging more than 10 MGD between Baltimore and the Bay Bridge.

Industrial Waste Discharges--

Permits for discharges required under the National Pollutant Discharge Elimination System (NPDES) are issued by the Waste Management Administration, OEP, for industrial waste, and by the Water Management Administration, OEP, for sewage treatment plants.

Industrial dischargers must use best practicable control technology, and proposed discharges must be consistent with the state's water quality standards. Permit issuance, compliance monitoring, and enforcement of permits is carried out by the Waste Management Administration, OEP.

Publicly-Owned Sewage Treatment Works--

The Water Management Administration also issues NPDES permits for publicly-owned sewage treatment plant discharges. In addition, sewage treatment plants must comply with county water and sewer plans, which are prepared at the county level, and approved by the Water Management Administration. The Water Management Administration monitors all permitted sewage treatment plant effluents at least monthly, in cooperation with county health departments. The majority of sewage treatment facilities are owned and operated by local county and municipal agencies. Local treatment works may apply for Federal funding under Section 201 of the CWA, which provides up to three-quarters of planning, design, and construction costs. The Federal share will be reduced to 55 percent after October 1, 1984. The Water Management Administration, OEP, is the lead agency for implementation of the 201 program in Maryland and oversees plant planning and construction.

The Water Management Administration also administers a state grant program which provides up to 12.5 percent of publicly-owned sewage treatment facility construction costs. The Health Hazard Abatement Grant Program, which funds sewage treatment facilities needed to eliminate health risks due to failing on-site sewage treatment systems, is also administered by the Water Management Administration.

The Maryland Environmental Service, DNR, also owns and maintains sewage treatment facilities and hazardous waste facilities. Both the DNR and the OEP may order the Maryland Environmental Service to intervene if locally operated treatment facilities fail to comply with state standards.

Privately-Owned Sewage Treatment Works--

The Water Management Administration also regulates the construction and operation of individual sewage disposal systems and requires provision of treatment facilities prior to construction of subdivisions.

On-Site Sewage Disposal--

Individual septic system construction is regulated by the Water Management Administration through county health departments. County water and sewer plans document septic failures attributable to small lots, high water tables, poor percolation, and steep slopes.

Area-wide Waste Management Planning--

The Water Management Administration, OEP, has primary responsibility for the formulation of area-wide waste management plans required by Section 208 of the Federal Water Pollution Control Act, except in the Baltimore and Washington metropolitan regions, where the responsibility was delegated to the Regional Planning Council and the Metropolitan Washington Council of Governments, respectively. The State Soil Conservation Committee, Department of Agriculture, works with the Water Management Administration in the preparation and implementation of the state-wide Agricultural 208 Plan for the control of sediment and animal waste. Table 4 summarizes Maryland programs for controlling nonpoint source pollution.

Agricultural Runoff--

Through the 208 program, the state has developed a strategy for controlling sediment and animal waste from agricultural runoff. This strategy was prepared with the cooperation of the State Soil Conservation Committee (SSCC) with the cooperation of many other organizations. The SSCC has lead responsibility for identifying priority areas where the potential for water pollution from agriculture is great and for identifying appropriate Best Management Practices (BMPs) for controlling sediment and animal wastes; both BMPs and the potential critical watershed have been identified and an implementation strategy is presented in the state-wide Agriculture Plan. In support of this program, the OEP maintains regular representation on the SSCC and offers assistance to the SSCC in overcoming obstacles to implementation of this program.

In addition to these state priority areas, local Soil Conservation Districts (SCD's) have mapped in detail their local "critical areas." The SCD's work to promote the development of voluntary soil conservation and water quality plans by farmers.

In 1982, a law was passed which set up a Maryland agricultural cost-sharing program to supplement the Federal cost-sharing program run by the USDA's Agricultural Stabilization and Conservation Service. The program, to which 5 million dollars were allocated, is to be administered by the Maryland Department of Agriculture (MDA) and the Offices of Environmental Programs (OEP), Department of Health and Mental Hygiene. The OEP is mandated to develop criteria for eligible projects to recieve the cost-share assistance, while the MDA will serve as the link to farmers and administer the distribution of funds.

Additional information on agricutlural and other nonpoint source problem areas in Maryland and current state projects funded by EPA's Region III are included in Section 3 of this appendix.

The Department of Agriculture administers the pesticide and pest

TABLE 4. MARYLAND PROGRAMS FOR CONTROLLING MAJOR NONPOINT SOURCES

| NPS Type | Date and Basis for Program | Mandatory? | Agency Responsibility | Comments |
|---|---|---|---|---|
| agricultural pollution (sediment, fertilizer & waste, etc.) | 1940s-SCDs-state law SCS/ASCS-fed. law<br>1979 -State 208 Agriculture Plan (no law)<br>1982 -State funded cost-share law (unprecedented in MD) | no | technical assistance SCDs/SCS<br>Cost-share ASCS (fed)<br>OEP/MDA (State)<br>OEP preparing to do ongoing, modest research | -SCDs committed but understaffe<br>-1970's & 1980's breathing new life in the program (State cost-share is big boost) eventual result unknown now but outlook is hopeful |
| sediment control (construction, surface mining) | 1970 -State sediment control law (no State funds to local agencies) | yes (farms exempt) | SCD-plan approval counties - enforcement oversight by WRA | -programs vary greatly from county to count<br>-individual county programs fluctuate in quality over ti<br>-State must monitor regularly - endlessly |
| urban runoff (new development) | 1970s-local ordinances in urban counties<br>1977 -WRA "policy"<br>1982 -State stormwater law (no State funds to locals) | yes | counties (plan review, watershed planning enforcement) oversight, research by WRA (State $, FEMA $) | -program being developed by WRA<br>-most urban counties have quantity oriented guidelines<br>-State agencies accepting |
| urban runoff (older areas) | no law | no | only incidental to other local functions | little being don |
| urban runoff (industrial) | 1972 -Clean Water Act (NPDES program) | yes | OEP makes runoff treatment a condition of many industrial permits | |

(continued)

TABLE 4. (Continued)

| NPS Type | Date and Basis for Program | Mandatory? | Agency Responsibility | Comments |
|---|---|---|---|---|
| hazardous waste sites | 1976 -State Hazardous Substances Act<br>Federal RCRA<br>1980 Hazardous Waste Siting Board | yes | OEP (with EPA) | -aggressive action on large older sites<br>-stringent new criteria for new sites<br>-State ownership and operation of major hazardous waste sites |
| septic system | old State law, local law | yes | OEP, local health departments | -design criteria have gotten more stringent in 1970's |

NOTES:

| | |
|---|---|
| NPS: | Nonpoint source |
| SCD: | Soil Conservation Districts (county-level) |
| SCS/ASCS: | Soil Conservation Service/Agricultural Stabilization and Conservation Service (federal) |
| WRA: | Maryland Water Resources Administration |
| OEP: | Maryland Office of Environmental Programs |
| MDA: | Maryland Department of Agriculture |

control program, which requires registration and proper packaging and labelling of pesticides, as well as proper application of pesticides.

Urban Runoff--

Maryland does have a comprehensive program to address stormwater runoff in existing areas. The Water Resources Administration, DNR, has the lead responsibility for addressing the quantity impacts of stormwater runoff, including flooding, while the Water Management Administration, OEP, is responsible for stormwater impacts on water quality. Under a state law passed in 1982, counties are required to have a stormwater management program by July 1, 1984.

The state's current strategy for urban nonpoint sources of water pollution rests on (1) a continuing review of the evolving body of knowledge relating to the mitigation of the urban runoff impacts, (2) an investigation of the legal, institutional, and economic aspects of establishing effective stormwater management programs at the state and local levels, and (3) a program of "technology transfer" for the purpose of sharing this knowledge with concerned citizens, local officials, and other state agency officials in Maryland. Only limited staff resources have been available for this work.

Runoff from Construction Activities--

State law and regulations require sediment and erosion control measures for construction activities in general, as well as for timber-harvesting operations and surface-mining activities. Under the existing state program, each county or municipality must adopt grading and building ordinances necessary to carry out the sediment control program and submit them to the Water Resources Administration, DNR, for approval. Local ordinances require that a person obtain a grading or building permit before any clearing, construction, or development may begin. One requirement for receiving such a permit is that the developer submit an erosion and sediment control plan, which must be approved by the local Soil Conservation District.

Land clearing or construction activities carried out by a state agency require Department of Natural Resources approval. The OEP has entered an agreement with the Water Resources Administration, DNR, to work cooperatively in implementing and enforcing sediment and erosion control programs. The OEP is responsible for "sediment as a pollutant" (after it has entered a waterway), and will notify the Water Resources Administration of any apparent sediment and erosion control plan violations which are observed.

Surface Mining--

The surface mining of minerals, including sand and gravel, are regulated by the Water Resources Administration, DNR, under the Maryland Surface Mining Act of 1975.

Dredging, Filling, and Spoil Disposal--

The Department of Natural Resources regulates the dredging and filling of private wetlands and the state Board of Public Works regulates the dredging and filling of state wetlands.

Federal permits are requried from the U.S. Army Corps of Engineers for the discharge of dredged material into navigable waters, or to build any structure, to excavate, or to deposit any material in navigable waters. Spoil material dredged from the bottom of Chesapeake Bay to maintain maritime shipping channels is currently disposed of on land or in diked containment areas.

The Department of Natural Resources has entered into an agreement with the Corps of Engineers, providing for joint processing of state and Federal permits. In addition, the Corps is required to consult with state agencies and consider state policy when making determination on permit applications.

The Federal Water Pollution control Act provides for delegation of the Federal permit program for dredged and fill material to the individual states. Corps of Engineers permits are required for spoil disposal containment sites under Section 9 and 10 of the Rivers and Harbors Act of 1899. In addition, permit applications for activities affecting Maryland's coastal zone certification are available from the Coastal Resources Division of the DNR.

Discharges from dredging and spoil disposal operations are regulated by the OEP under the state's general authority to control water pollution. The Department of Natural Resources administers a permit program specifically for approval of Baltimore Harbor dredge spoil disposal sites.

Major dredging projects are primarily Federally funded and carried out by the Corps of Engineers. However, the state is required to provide suitable sites for spoil containment and to fund disposal operations. The Department of General Services is responsible for approving all contracts, plans, and specifications for public improvement projects and has been designated as the lead agency in supervising the construction of spoil disposal sites.

Dredging operations on a smaller scale are carried out by the Capital Programs Administration of the Department of Natural Resources.

Shipping -- Oil Spills--

The Department of Natural Resources is empowered to regulate facilities involved in receiving, transferring or discharging oil in order to prevent and control potential oil spills. The Maryland Port Administration has some regulatory power over vessels transporting oil. In addition, the Maryland Port Administration is responsible for developing programs to prevent and control oil spills in the Baltimore Harbor Area.

A license from the Department of Natural Resources is required to operate an oil terminal facility in Maryland. License fees and revenue from fines are credited to the Maryland Oil Disaster Containment, Clean-Up, and Contingency Fund, which is utilized for oil spill prevention, control, and clean-up. Bonding requirements, implemented by the Maryland Port Administration, are imposed upon vessels carrying oil in Maryland waters. Oil spill prevention and control programs are carried out in conjunction with the U.S. Coast Guard. The Port Administration has enacted regulations governing the operation of vessels in Baltimore Harbor.

Boating -- Sewage--

The dumping of refuse by boaters is specifically prohibited by Maryland law.

Shoreline Erosion--

The Wetlands Act of 1970 allows owners of waterfront property to make improvements into the water in front of their land to preserve their access to navigable water or protect their shore against erosion. Before constructing soreline improvements, the land owner is required to notify the Department of Natural Resources. In projects involving the filling of state wetlands, a permit from the state Board of Public Works is required.

The Department of Natural Resources provides interest-free loans for the construction of approved shore erosion control structures through the Shore Erosion Control Construction Load Fund. Under this program, the department designs and supervises shore erosion projects, provides technical assistance to property owners, and administers the loan fund. Political subdivisions, as well as individual land owners, may apply for funds. Each proposed project is then assigned a priority number based on the rate of erosion, anticipated public benefit, and other factors. Loans are repaid through a special tax levied on the benefitted property.

Hazardous Waste--

The "Safe Disposal of Designated Hazardous Substances Act" is administered by the Waste Management Administration, OEP. The act imposes general requirements with regard to the operation of hazardous waste treatment, storage, and disposal facilities. Persons who utilize or dispose of hazardous wastes must supply the Waste Management Administration, OEP, with a report identifying the type and quantity of substances involved, the proposed management or disposal methods, and detailed information concerning the location and characteristics of the proposed disposal site. To obtain department permits, hazardous waste facilities must comply with facility design and capacity standards, undergo periodic monitoring by the department, establish emergency procedures in case of accidents, maintain adequate liability insurance, and provide evidence of financial ability to properly operate and maintain a facility. Additional department certification is required to transport designated hazardous substances.

Resources Management--

Fisheries Management--Detailed and comprehensive standards governing commercial and sport fisheries in the Chesapeake Bay are implemented by the Department of Natural Resources. In addition, the Department of Natural Resources has the authority to promulgate fisheries regulations in several specified subject areas, such as the blue crab fishery, the taking of oysters from natural bars during closed season, and the restricting the harvesting of striped bass during spawning season.

The Department of Natural Resources issues licenses to commercial fishermen, crabbers, oystermen, and clammers in tidal waters. Money received as commercial license fees, in addition to taxes, royalties paid for oyster and clam shells removed from state waters, and fines levied on commercial fishermen, are credited to the Fisheries Research and Development Fund. This fund is used for research and the replenishment of fisheries resources.

The Department of Natural Resources coordinates an extensive oyster culture program in the Chesapeake. Funds appropriated for oyster propagation are used to finance the planting of oyster shells, cultch, and seed oysters on the natural bars of the state.

The Department of Natural Resources is also authorized to acquire property to be utilized as "state fish refuges" to protect, propagate, or manage fish in tidal or non-tidal waters.

The Commercial Fisheries Advisory Commission and the Sports Fisheries Advisory Commission, both appointed by the Governor, consult with the Department of Natural Resources in the formulation of fisheries policy. In addition, the DNR is authorized to enter into agreements with other states to better manage fisheries.

Authority to restrict commercial harvesting of shellfish is shared by the Department of Natural Resources and the Office of Environmental Programs of the Department of Health and Mental Hygiene. Particular areas may be closed as a conservation measure to promote increased productivity. Harvesting may also be prohibited in localities where water pollution poses a potential health hazard.

The Department of Natural Resources is required to take measures to increase the productivity or utility of the state's natural oyster base. This may include a prohibition against harvesting oysters in specified areas. Similar regualtions apply to closure of clamming grounds. Harvesting restrictions are enforced by the Natural Resources Police.

Wetlands Management--The Wetlands Act of 1970 authorizes the Department of Natural Resources to regulate dredging and filling of private wetlands. Dredging and filling of wetlands is engaged in by private firms to provide additional suitable land for agriculture and other uses, and for the purpose of mining sand and gravel. Filling includes the artificial alteration of navigable water levels by any physical structure. This encompasses the construction of shoreline erosion projects.

Public agencies also undertake dredging projects to create and maintain shipping channels. Public projects are described in the survey of dredging and spoil disposal activities. The state Board of Public Works has similar regulatory responsibilities over the dredging and filling of state wetlands. "State wetlands" include all land under the navigable waters of the state below mean high tide affected by the regular rise and fall of the tide. "Private wetlands" are defined as any land not considered a state wetland, bordering on or lying beneath tidal waters, which is subject to regular or periodic tidal action and supports aquatic growth. An inventory of wetlands in the state has been prepared by the Department of Natural Resources. The State Wetlands Program is coordinated with the Federal permit program for dredging and filling.

## PENNSYLVANIA CONTROL PROGRAMS

### Introduction

The Pennsylvania Department of Environmental Resources (DER) is responsible for the regulation and development of the commonwealth's natural resources, including the management of activities that affect water and land resources, minerals, and outdoor recreation. The DER is also responsible for the control and abatement of water and air pollution. It is the management and control efforts within the Susquehanna River Basin, primarily, which affect the Chesapeake Bay.

## The DER Organization

The Pennsylvania General Assembly created the DER through ACT 275 of December 3, 1970. The Department was activated in January 1971 by abolishing the Department of Forests and Waters, and Mines and Mineral Industries, and by transferring specific powers from the Departments of Agriculture, Health, Labor, and Industry, and the state Planning Board (Figure 1). Act 275 also established the following:

### The Citizens Advisory Council--

The Citizens Advisory Council consists of 19 members, including the DER secretary, and six representatives chosen by the Governor, the speaker of the House, and the president pro tempore of the Senate. The members are unpaid volunteers who seek to increase citizen participation in the department's decisions. The CAC is charged by law with: reviewing all environmental laws and making appropriate suggestions for their review, modification, and codification; reviewing the work of the department and making recommendations for improvement; and reporting annually to the Governor and the Legislature.

### The Environmental Hearing Board--

The Environmental Hearing Board is an independent three-member body of lawyers, appointed by the Governor with the advice and consent of the Senate. It holds public hearings and issues adjudications on orders, permits, licenses, or decisions of the department.

### The Environmental Quality Board--

The Environmental Quality Board is a 21-member panel of state agency officials, legislators, and citizens. It is responsible for developing the Environmental Master Plan, formulating and adopting rules and regulations governing department programs, and advising the department on policy issues. The DER is organized into six major offices (Figure 6) reporting to the Secretary of the DER. These offices and associated responsibilities are:

Office of Administration--This office provides direction and review of staff support services for the department's administrative activities.

Office of Chief Counsel--This office is the department's legal agency, representing the department in courts and before the Environmental Hearing Board and offering legal advice and services to the department.

Office of Environmental Protection--This office is responsible for:

1) Identifying air pollution problems and solving them through pollution control requirements, monitoring and meteorological services, and air pollution emergency control programs.

2) Administering state-wide environmental health programs concerning water supplies, food protection, recreation facilities, nursing homes, schools, mobile home parks, seasonal farm labor camps, and rodent and insect control.

3) Providing analytical services to the environmental regulatory, planning, and advisory programs of the department.

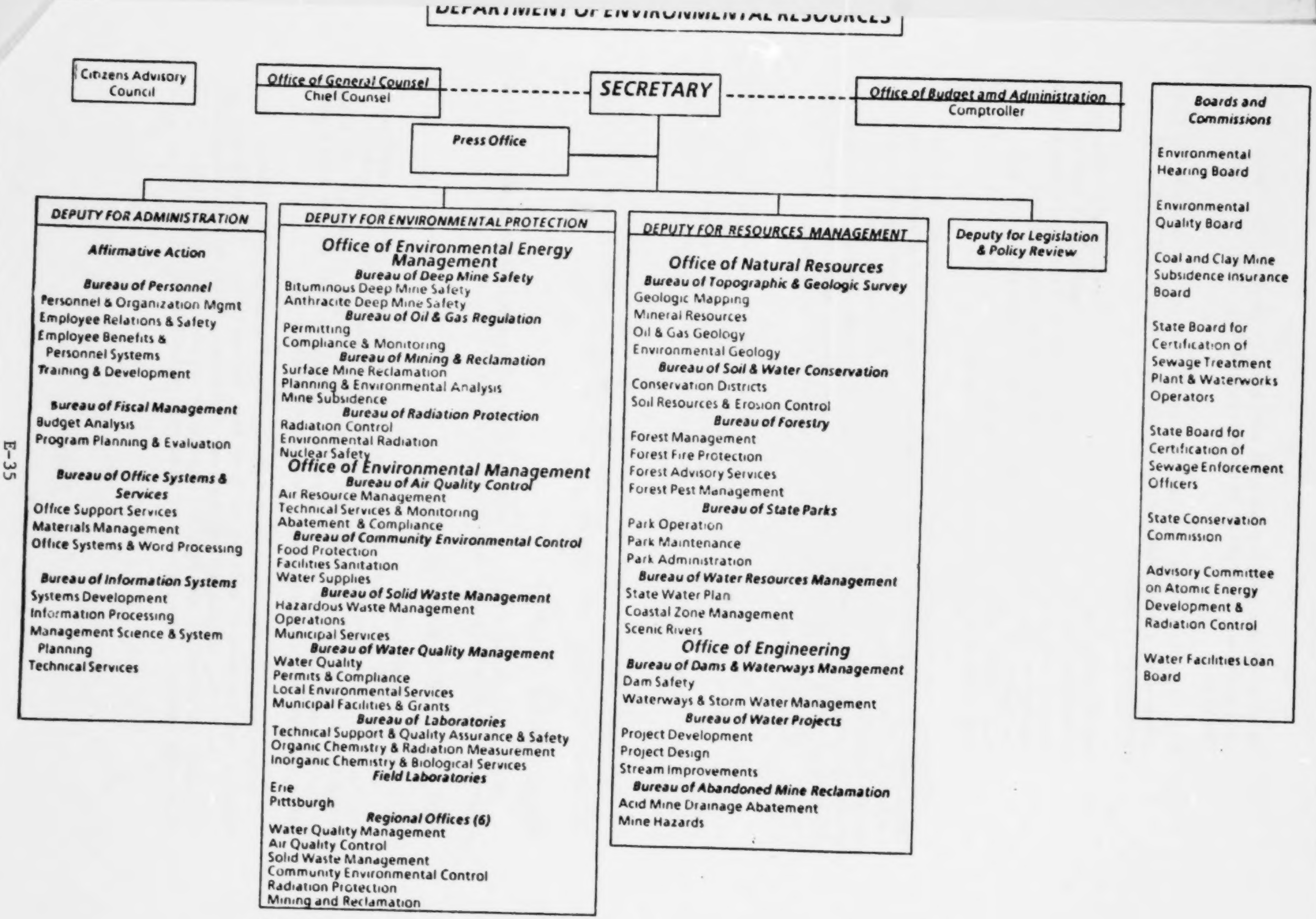

DEPARTMENT OF ENVIRONMENTAL RESOURCES
Citizens Advisory Council
Office of General Counsel
Chief Counsel
SECRETARY
Office of Budget amd Administration
Comptroller
Press Office
DEPUTY FOR ADMINISTRATION
Affirmative Action
Bureau of Personnel
Personnel & Organization Mgmt
Employee Relations & Safety
Employee Benefits & Personnel Systems
Training & Development
Bureau of Fiscal Management
Budget Analysis
Program Planning & Evaluation
Bureau of Office Systems & Services
Office Support Services
Materials Management
Office Systems & Word Processing
Bureau of Information Systems
Systems Development
Information Processing
Management Science & System Planning
Technical Services
DEPUTY FOR ENVIRONMENTAL PROTECTION
Office of Environmental Energy Management
Bureau of Deep Mine Safety
Bituminous Deep Mine Safety
Anthracite Deep Mine Safety
Bureau of Oil & Gas Regulation
Permitting
Compliance & Monitoring
Bureau of Mining & Reclamation
Surface Mine Reclamation
Planning & Environmental Analysis
Mine Subsidence
Bureau of Radiation Protection
Radiation Control
Environmental Radiation
Nuclear Safety
Office of Environmental Management
Bureau of Air Quality Control
Air Resource Management
Technical Services & Monitoring
Abatement & Compliance
Bureau of Community Environmental Control
Food Protection
Facilities Sanitation
Water Supplies
Bureau of Solid Waste Management
Hazardous Waste Management
Operations
Municipal Services
Bureau of Water Quality Management
Water Quality
Permits & Compliance
Local Environmental Services
Municipal Facilities & Grants
Bureau of Laboratories
Technical Support & Quality Assurance & Safety
Organic Chemistry & Radiation Measurement
Inorganic Chemistry & Biological Services
Field Laboratories
Erie
Pittsburgh
Regional Offices (6)
Water Quality Management
Air Quality Control
Solid Waste Management
Community Environmental Control
Radiation Protection
Mining and Reclamation
DEPUTY FOR RESOURCES MANAGEMENT
Office of Natural Resources
Bureau of Topographic & Geologic Survey
Geologic Mapping
Mineral Resources
Oil & Gas Geology
Environmental Geology
Bureau of Soil & Water Conservation
Conservation Districts
Soil Resources & Erosion Control
Bureau of Forestry
Forest Management
Forest Fire Protection
Forest Advisory Services
Forest Pest Management
Bureau of State Parks
Park Operation
Park Maintenance
Park Administration
Bureau of Water Resources Management
State Water Plan
Coastal Zone Management
Scenic Rivers
Office of Engineering
Bureau of Dams & Waterways Management
Dam Safety
Waterways & Storm Water Management
Bureau of Water Projects
Project Development
Project Design
Stream Improvements
Bureau of Abandoned Mine Reclamation
Acid Mine Drainage Abatement
Mine Hazards
Deputy for Legislation & Policy Review
Boards and Commissions
Environmental Hearing Board
Environmental Quality Board
Coal and Clay Mine Subsidence Insurance Board
State Board for Certification of Sewage Treatment Plant & Waterworks Operators
State Board for Certification of Sewage Enforcement Officers
State Conservation Commission
Advisory Committee on Atomic Energy Development & Radiation Control
Water Facilities Loan Board

Figure 6. Pennsylvania Department of Environmental Resources organizational chart

4) Enforcing laws and regulations designed to protect the environment from problems associated with surface mining, both coal and non-coal.

5) Planning, directing, evaluating, coordinating, and organizing the state-wide waste management, including resource recovery, and enforcement program.

6) Maintaining and improving the quality of Pennsylvania's water resources for the support of planned and probable uses and to protect the public health. The Office of Environmental Protection maintains six regional offices which are responsible for implementing and enforcing Pennsylvania's environmental laws. They handle complaints, permit applications, inspections, and environmental accidents in their regions.

Office of Resources Management--This office is responsible for the management of the state's natural resources. This includes recreation, forestry, flood control, water resources planning and development, and related engineering and operations activities. It also is responsible for water obstructions and encroachments, flood-plain management, stormwater management, erosion and sediment control, dam safety and water allocations, and for surveys of the geology, mineral resources, topography, and ground-water resources in the state.

Office of Planning--This office is responsible for planning and program policies, Congressional liaison, environmental review and economics, emergency planning, interstate and international boards and commissions, environmental impact analyses, and development of the state environmental master plan and Pennsylvania's recreation plan.

Office of Deep Mine Safety--This office is responsible for enforcing the anthracite and bituminous coal mining laws which provide for the health and safety of underground mines.

## Regulations and Standards

Table 5 provides a list of DER regulations and standards governing the Department's Water Quality Management activities.

## Water Quality Management Activities

### Water Quality Standards--

Water quality standards for surface and ground waters in Pennsylvania are developed and periodically revised by the Bureau of Water Quality Management, Office of Environmental Protection. These standards are based on designated water uses within a stream segment or zone in the basin and water quality criteria necessary to protect those uses.

Water quality criteria for the protection of aquatic life, water supply, and state-wide recreation have been established. The criteria include bacteria, dissolved oxygen, pH, turbidity, total dissolved solids, nitrogen, phosphorus, and metals. Specific criteria for water uses requiring special protection have also been established.

TABLE 5. REGULATIONS AND STANDARDS OF THE PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

| Regulations/Standards | | Guidelines Provided |
|---|---|---|
| Chapter 91. | General Provisions | Provides general administration and enforcement guidelines for the Department of Environmental Resources which relate to water quality. |
| Chapter 92. | National Pollutant Discharge Elimination System | Sets standards and regulations for the administration of this system in Pennsylvania. |
| Chapter 93. | Water Quality Criteria | Sets forth water quality criteria for the waters of Pennsylvania. These criteria are utilized in the Department of Environmental Resources enforcement program. |
| Chapter 95. | Waste Water Treatment Requirements | Sets forth specific treatment requirements to meet specified water quality criteria. |
| Chapter 97. | Industrial Wastes | Provides standards and regulations for the treatment of industrial wastes. |
| | Spray Irrigation Manual | Provides guidelines for site selection, system design, and preparation of plans and reports. |
| Chapter 99. | Mine Drainage | Provides standards and regulations for the treatment of mine drainage. |
| Chapter 101. | Special Water Pollution Regulations | Provides special water pollution control regulations for the following activities:<br>- Incidents causing or threatening pollution;<br>- Activities utilizing polluting substances;<br>- Impoundments;<br>- Algicides, herbicides, and fish-control chemicals. |
| Chapter 102. | Erosion Control | Sets forth rules, regulations, and standards to control erosion and the resulting sedimentation in the waters of Pennsylvania. |

(continued)

TABLE 5. (Continued)

| Regulations/Standards | Guidelines Provided |
|---|---|
| Chapter 103. Sub-chapter A. Federal Grants for Construction of Sewage Facilities | Provides guidelines and eligibility standards for obtaining Federal grants for sewer projects. |
| Chapter 71. Administration of Sewage Facilities Act | Provides rules and regulations for the administration of the Sewage Facilities Act. Provides guidelines for preparation of sewage facilities plans. |
| Chapter 73. Standards for Sewage Disposal Facilities | Provides standards and regulations for on-lot sewage disposal facilities. |
| Chapter 77. Mining | Sets forth rules and regulations for the reclamation and planting of areas affected by open pit mining of bituminous and anthracite coal. Also sets requirements for operations of surface coal mining activities. |
| Chapter 301. General Provisions State Board for Certification of Sewage Treatment Plant and Waterworks Operators | Sets forth administration regulations for administering the act. |
| Chapter 303. Certification of Operators | Sets forth regulations and standards for certification of operators of sewage treatment plants and waterworks. |
| Chapter 103. Financial Assistance Sub-chapter B. State Grants for Operation of Sewage Treatment Plants | Provides regulations for state grants to municipalities for the operation of sewage facilities. |
| Chapter 103. Financial Assistance Sub-chapter D. State Grants for Construction of Sewage Facilities | Provides regulations for awarding of state grants for the planning, design, and construction of sewage facilities. |

(continued)

TABLE 5. (Continued)

| Regulations/Standards | Guidelines Provided |
|---|---|
| Chapter 75. Solid Waste Management | Provides standards and guidelines for a variety of solid waste functions including:<br>- Preparation of solid waste management plans;<br>- Granting permits;<br>- Sanitary landfill standards;<br>- Collection and transportation of solid wastes. |
| Chapter 76. Solid Waste Resource Recovery Development | Provides guidelines for obtaining loans for the Department of Environmental Resources for disposal/processing systems and resource recovery systems. |
| Chapter 125. Coal Refuse Disposal Areas | Provides rules and regulations for operating a coal refuse disposal area and obtaining a permit from the Department of Environmental Resources under the provisions of the Air Pollution Control Act. |
| Chapter 100. Mine Resources Management | Provides rules and regulations for operating a coal refuse disposal area and obtaining a permit from the Department of Environmental Resources under the provisions of the Clean Streams Act. |
| Chapter 79. Oil and Gas Conservation | Provides rules and regulations for wel drilling operations and permits. |
| Chapter 193. Public Swimming and Bathing Places | Sets forth rules and regulations governing operations and issuance of permits for public swimming and bathing places. |
| Chapter 109. Waterworks | Sets forth standards and regulations for construction, maintenance, and operation of waterworks. Also provide regulations for obtaining permits for waterworks. |

Discharge Permit Program--

Point source discharges from industrial waste treatment facilities and both publicly and privately-owned sewage treatment facilities are controlled under the National Pollutant Discharge Elimination System (NPDES) by the Bureau of Water Quality Management, Office of Environmental Protection. The NPDES permit applications are processed at regional offices. Effluent limitations for the treatment facilities are established in accordance with the water quality standards for the receiving waters. Monthly monitoring reports must be submitted to the DER regional offices. Waste treatment facilities must be consistent with area-wide waste management plans and with municipal or county sewer plans.

The DER requires at least 80 percent phosphorus removal by all new or modified wastewater treatment facilities discharging to tributaries and the main stem of the Susquehanna River in a zone between the confluence of, but not including, the Juniata River and the Pennsylvania-Maryland state-line.

On-Lot Waste Treatment Facilities--

The Bureau of Water Quality Management administers the program for individual and community on-lot sewage disposal systems. Pennsylvania requires that all on-lot sewage disposal systems be issued a permit by a certified sewage enforcement officer employed by the municipality or municipalities in which the system is to be installed. In addition, DER concurrence is required for on-lot disposal systems for any facility, establishment, or institution for public use and for all experimental on-lot systems.

Construction Grants Program--

The Division of Municipal Facilities and Grants, Bureau of Water Quality Management, Office of Environmental Protection manages the allocation of Federal grant funds for the planning and construction of publicly-owned treatment works.

The DER annually prepares a project priority list, in conformance with Federal requirements for submittal of such lists, and schedules public hearings prior to submitting the priority list for EPA approval. The fundable portion of the list contains projects in priority order planned for funding during the fiscal year to the extent of the total funds expected to be available during the Federal fiscal year.

Priority among the eligible projects is established according to the applicant's accumulation of priority points for each of the following rating factors:

- o Stream-segment priority
- o Water-pollution control
- o Population affected

Priority points are assigned to each of the rating factors as follows:

(1) Stream segment priority rating factor -- maximum 10 pts.

- o Category I -- water quality segments with existing sewerage systems, including treatment plants, and experiencing growth rates at or above state-wide average; excluding mine drainage affected streams not scheduled for reclamation projects (10 pts).

- o Category II -- water quality segments with growth rates below the state-wide average or identified as "special protection" streams (7 pts).

- o Category III -- effluent limitation segment (4 pts).

- o Category IV -- water quality segments affected by acid mine drainage from abandoned coal mines (1 pt).

(2) Water pollution control rating factor -- maximum 8 pts (Table 6).

TABLE 6. SUMMARY OF WATER POLLUTION CONTROL USE-FACTOR RATINGS

| | No Effect | Slight Effect | Moderate Effect | Great Effect |
|---|---|---|---|---|
| Community Environment and Aesthetics | 0 | (See Matrix)* | | 24 |
| Domestic Water Supply | 0 | 5 | 10 | 18 |
| Fish and Aquatic Life | 0 | 5 | 8 | 14 |
| Public Bathing | 0 | 1 | 3 | 8 |
| Boating and Recreation | 0 | 1 | 3 | 5 |
| Industrial Water Supply | 0 | 1 | 3 | 5 |
| Irrigation | 0 | 1 | 2 | 3 |
| Stock Watering | 0 | 1 | 2 | 3 |

*A maximum of 24 points can be assigned to the Community Environment and aesthetics use-factor. A matrix is used to assign priority points based on the extent of malfunctioning on-lot systems; occurrences of inadequately treated or untreated sewage in publicly accessible areas; or untreated or inadequately treated sewage discharges to surface streams from overload sewage conveyance facilities and treatment plants.

(3) Population affected rating factor -- maximum 10 pts.

| Project Equivalent Population | Priority Points |
|---|---|
| 1 - 3,500 | 6 |
| 3,501 - 5,000 | 7 |
| 5,001 - 10,000 | 8 |
| 10,001 - 50,000 | 9 |
| greater than 50,000 | 10 |

Project Equivalent Population is the initial population equivalent which would be served by the project at the time that the project is rated. Small communities (less than 3,500) are rated for stream segment priority and water-pollution control in the same manner as the larger communities, but 9 points must be assigned for the population affected factor.

DER's financial aid activity includes administration of funds available through the Sewage Facilities Act (Act 208), the Clean Streams Act (Act 394), the Land and Water Conservation and Reclamation Act (Act 443), and the Federal Clean Water Act (PL 95-217). The Sewage Facilities Act provides 50 percent of the financial assistance to local governments for the preparation of sewage facilities plans. These plans establish the extent of existing public sewage systems and recommend future required facilities. The Clean Streams Act provides a 2 percent subsidy for costs of plant operation, maintenance, and replacement of new sewage facilities. The Land and Water Conservation and Reclamation Act provides for grants of 5 percent for eligible projects.

Agriculture and Earth-Moving Activities--
The state-wide 208 Plan for Agriculture and Earthmoving Activities was approved in 1979. This plan deals with erosion and sedimentation, manure management, aquatic vegetation herbicide control, and pesticide control. In the erosion and sedimentation plan, DER regulations require that any land-owner, person, or municipality engaged in earthmoving activity develop, implement, and maintain erosion and sedimentation control measures. If the activity involves 25 or more acres of land, a special erosion and sedimentation permit from DER is required. No permit is required for activities involving less than 25 acres, but erosion and sedimentation control plans must be maintained at the site. All farmers must have either an erosion and sedimentation control plan or have applied to their county conservation district for the plan. The county conservation districts prepare plans on a priority basis giving high priority to those applicants with the most serious problems.

The program is administered jointly by two separate bureaus of the DER, the Bureau of Soil and Water Conservation (through its administrative ties with the State Conservation Commission), and the Bureau of Water Quality Management. The former reviews and evaluates the technical aspects of erosion control plans and the latter is responsible for enforcing the regulations.

The manure management program is run jointly by the DER Bureau of Water Quality Management, the Soil Conservation Service, and the Cooperative Extension Service. Approval or a permit is required, depending upon how the manure is handled. A study was recently completed (June 1983) entitled "An Assessment of Agricultural Nonpoint Source Polution in Selected High Priority Watersheds in Pennsylvania" by the DER Bureau of Soil and Water Conservation. Additional information on Pennsylvania's nonpoint source problem areas and current state projects funded by EPA's Region III are included in Section 3 of this appendix.

Comprehensive Water Quality Management Planning--
The Department of Environmental Resources is addressing this problem through the Comprehensive Water Quality Management Program (COWAMP). The Bureau of Soil and Water Conservation, Office of Resource Management, assists the Conservation Districts in implementation of conservation programs.

Mining Activities--
All mine operators must obtain an NPDES mine drainage permit from the Regional Environmental Protection Office. The Bureau of Resources Programming, Office of Resource Management, develops restoration and acid mine pollution abatement programs for abandoned mine areas.

Solid Waste Management--

Each municipality with a population density of 300 persons per square mile must submit an official plan to provide an adequate solid-waste management system for approval by the DER. A permit is required of any person, municipality or authority that proposes to use any land as a solid-waste processing or disposal area. An air pollution control permit may also be required. The Bureau of Solid Waste Management is responsible for planning, directing, evaluating, coordinating, and organizing the state-wide solid-waste management and enforcement program. The DER also administers a grant and loan program for development of resource recovery systems.

Air Pollution--

The Bureau of Air Quality Control is responsible for identifying air pollution problems and solving them through pollution control requirements, monitoring, meteorological services, and air pollution emergency control programs. An approved air quality plan is required before construction of any significant air pollution source is begun. An air quality temporary operating permit is required to perform acceptance testing, and to undergo a lengthy start-up and debugging period. This permit is valid for 60 days and may be extended. An air quality permit is required to operate any air pollution source.

## Water Resources Management

Pennsylvania Fish Commission--

The Pennsylvania Fish Commission administers and enforces laws relating to fishing and boating on Pennsylvania's waters. The Commission is also responsible for the propagation, distribution, and protection of fish life in Pennsylvania's lakes, streams, and rivers.

The Commission maintains a major interest in activities concerning the abatement and reporting of water pollution. Its staff of waterways patrolmen assist in this endeavor by reporting various incidents of water quality violations. Working with the DER, the Commission also reviews permit applications for mine drainage, stream clearance, channel relocation, dam construction, water allocation, erosion and sedimentation control, and farm pesticide runoff.

The Commission's Bureau of Fisheries and Engineering conducts fish cultural research to determine fish management programs appropriate for Pennsylvania. The Bureau investigates the effect of pollution upon existing aquatic life. The Bureau acquires and develops access areas along streams, river, and lakes for recreational fishing and boating.

Pennsylvania Game Commission--

The Pennsylvania Game Commission is responsible for wildlife management through the protection, propagation, and preservation of game, fur-bearing animals, and protected species of birds. The major water-related activity of the Commission is its management of approximately 1,100,000 acres of state game-lands used as wildlife habitat development areas. Many of these state game-lands contain natural ponds and man-made impoundments that support various wildlife species.

## VIRGINIA CONTROL PROGRAMS

### Introduction

The Commonwealth of Virginia holds title to the Chesapeake Bay and its tributaries from the Potomac River at Smith Point to the mouth of the Bay. The tidewater portion of the state extends eastward from the fall line, which runs approximately along a longitudual line from Washington, DC through Richmond. This portion contains one-third of the land mass in the state, but is home to sixty percent of the state's population. Hampton Roads is one of the great ports in the world.

The management and regulation of the resources and activities affecting this region involve many state agencies. Agencies with the greatest involvement in the management of water quality and water resources are the State Water Control Board, State Department of Health, and the Marine Resources Commission. The efforts of the Division of Industrial Development and the Virginia Port Authority can also have significant impact on the Chesapeake Bay Region. The Council on the Environment is closely involved with significant activities through the environmental impact review processes.

State Water Control Board--

The State Water Control Board (SWCB, Figure 7), regulates the quality of direct discharges into state water through the National Pollutant Discharge Elimination System (NPDES) permit program. Animal waste treatment facilities and some industries are controlled by no-discharge permits. Non-point source pollution abatement is addressed through area-wide water quality management planning. The water quality aspects of dredging and filling operations are the purview of the 401 Certification Program.

State Department of Health--

The State Department of Health has several programs which can impact the water quality of Chesapeake Bay. The classification of shellfish-growing areas and regulation of the public health aspects of the shellfish industry is the responsibility of this agency. The Health Department also inspects and approves solid and hazardous waste disposal sites and individual waste-treatment facilities. The agency also approves plans for publicly and privately-owned sewage treatment plants and inspects the facilities.

Marine Resources Commission--

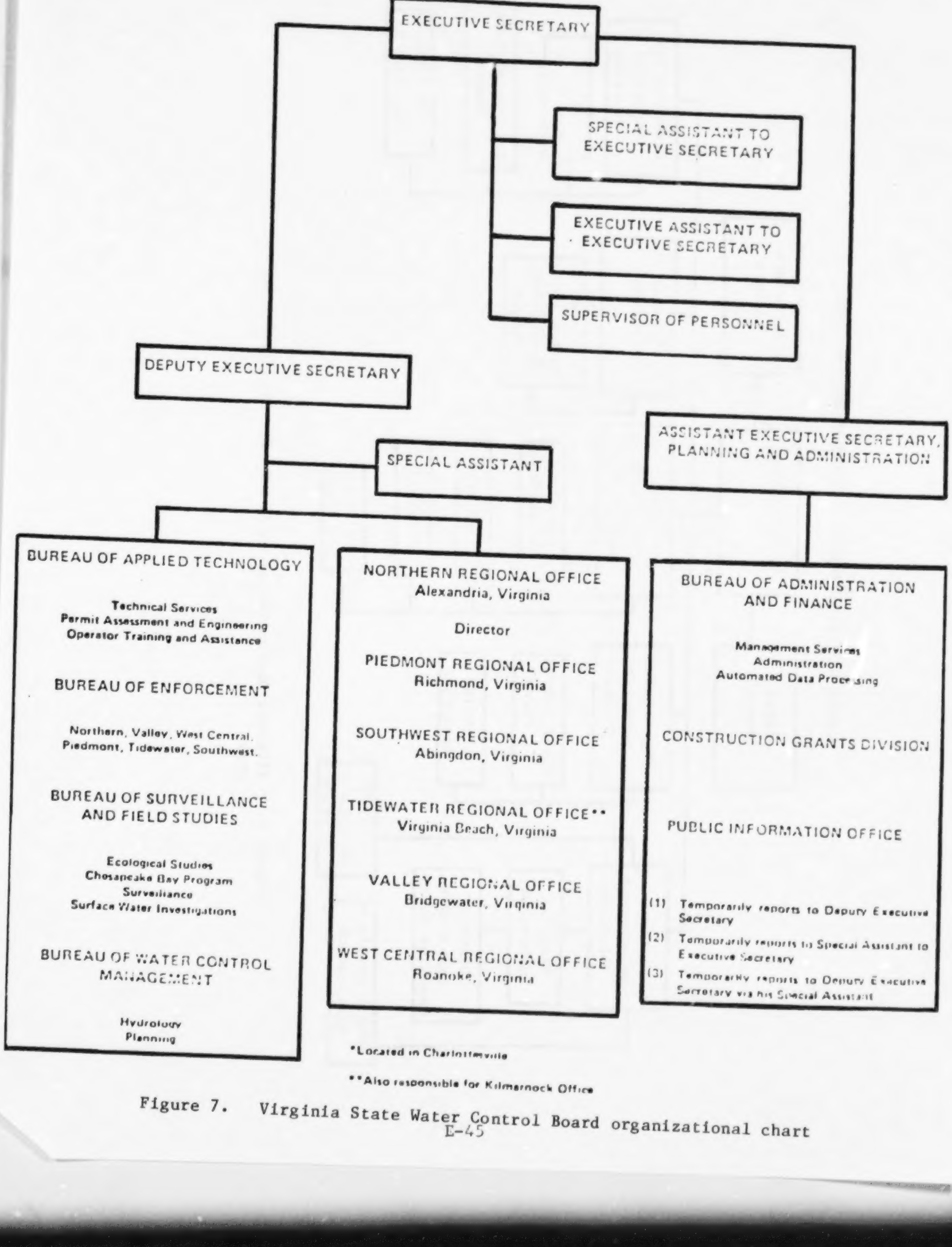
The regulation of the fisheries resource and the commercial fishing industry is the responsibility of the Marine Resources Commission (MRC), (Figure 8). The Commission administers a permit program and reviews all projects that have an impact on state-owned subaqueous bottoms. The Commission also has responsibility for administration of the Wetlands and Coastal Primary Sand Dunes Programs.

Virginia Port Authority--

The Virginia Port Authority and the Division of Industrial Development are both involved in encouraging industry to locate in Virginia and to utilize Virginia ports for international commerce. The success that these two agencies enjoy can logically have an effect on the activities of several of the state water quality programs.

# SWCB ORGANIZATIONAL CHART

*as of December 8, 1980*


EXECUTIVE SECRETARY
SPECIAL ASSISTANT TO EXECUTIVE SECRETARY
EXECUTIVE ASSISTANT TO EXECUTIVE SECRETARY
SUPERVISOR OF PERSONNEL
DEPUTY EXECUTIVE SECRETARY
SPECIAL ASSISTANT
ASSISTANT EXECUTIVE SECRETARY, PLANNING AND ADMINISTRATION
BUREAU OF APPLIED TECHNOLOGY
Technical Services
Permit Assessment and Engineering
Operator Training and Assistance
BUREAU OF ENFORCEMENT
Northern, Valley, West Central, Piedmont, Tidewater, Southwest.
BUREAU OF SURVEILLANCE AND FIELD STUDIES
Ecological Studies
Chesapeake Bay Program
Surveillance
Surface Water Investigations
BUREAU OF WATER CONTROL MANAGEMENT
Hydrology
Planning
NORTHERN REGIONAL OFFICE
Alexandria, Virginia
Director
PIEDMONT REGIONAL OFFICE
Richmond, Virginia
SOUTHWEST REGIONAL OFFICE
Abingdon, Virginia
TIDEWATER REGIONAL OFFICE**
Virginia Beach, Virginia
VALLEY REGIONAL OFFICE
Bridgewater, Virginia
WEST CENTRAL REGIONAL OFFICE
Roanoke, Virginia
BUREAU OF ADMINISTRATION AND FINANCE
Management Services
Administration
Automated Data Processing
CONSTRUCTION GRANTS DIVISION
PUBLIC INFORMATION OFFICE

(1) Temporarily reports to Deputy Executive Secretary

(2) Temporarily reports to Special Assistant to Executive Secretary

(3) Temporarily reports to Deputy Executive Secretary via his Special Assistant

*Located in Charlottesville

**Also responsible for Kilmarnock Office

Figure 7. Virginia State Water Control Board organizational chart

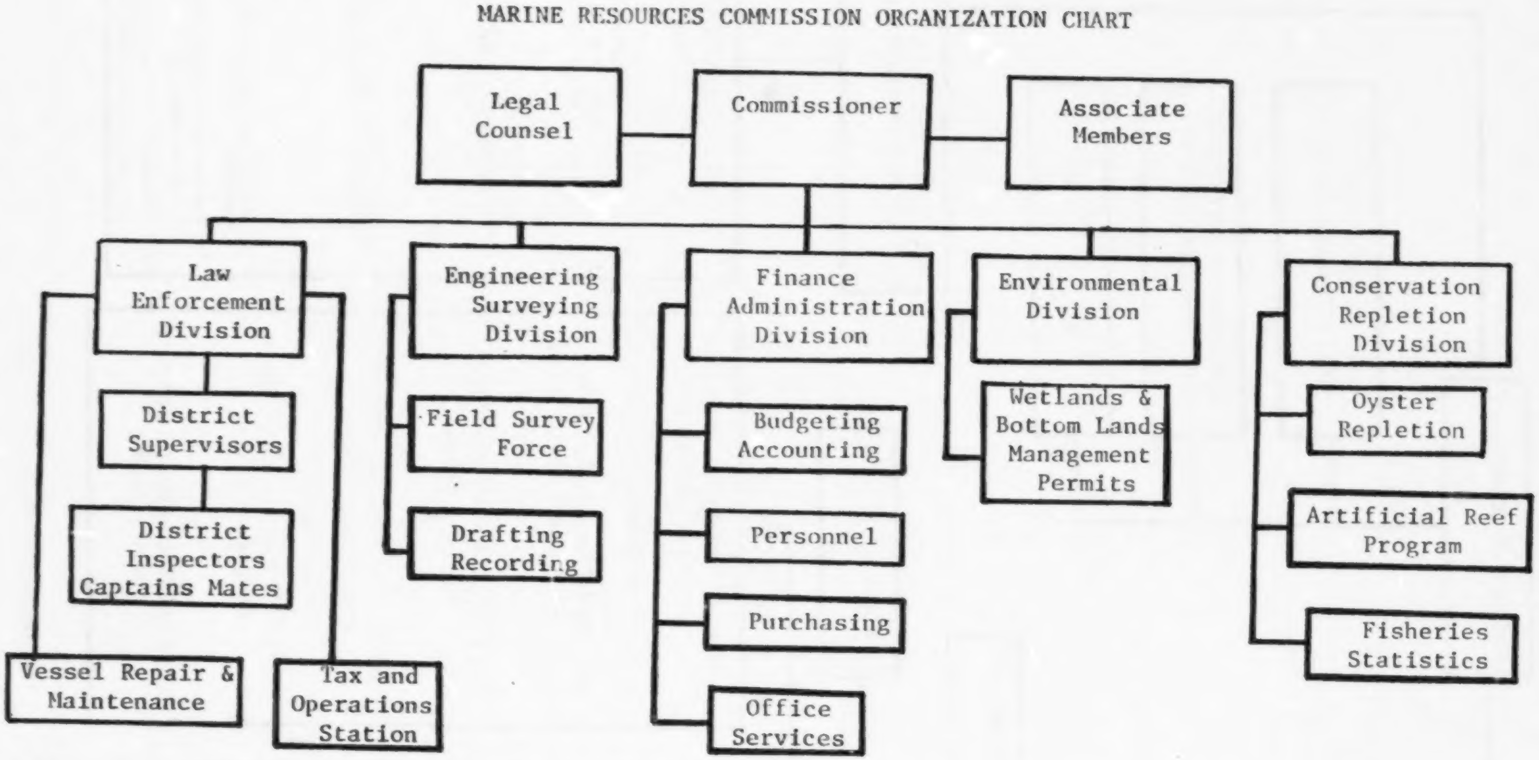

MARINE RESOURCES COMMISSION ORGANIZATION CHART
Legal Counsel
Commissioner
Associate Members
Law Enforcement Division
District Supervisors
District Inspectors Captains Mates
Vessel Repair & Maintenance
Tax and Operations Station
Engineering Surveying Division
Field Survey Force
Drafting Recording
Finance Administration Division
Budgeting Accounting
Personnel
Purchasing
Office Services
Environmental Division
Wetlands & Bottom Lands Management Permits
Conservation Repletion Division
Oyster Repletion
Artificial Reef Program
Fisheries Statistics

Figure 8. Virginia Marine Resources Commission organizational chart

Council on the Environment--

The Council on the Environment coordinates the state's review of environmental impact documents. The Council also provides comprehensive information on the environmental regulatory processes and requirements for potential developers.

State Air Pollution Control Board--

The State Air Pollution Control Board administers the state and Federal air quality regulations in Virginia. The Board has delegated responsibilities for the prevention of significant deterioration program and the hazardous pollutants program of the Clean Air Act. The agency regulates emissions from discrete sources through a permit program. An air monitoring network for particulate matter and gaseous compounds is operated to measure the ambient air quality. The State Air Pollution Control Board also has established an acid rain monitoring program.

## Water Quality Management Activities

Water Quality Standards--

The Water Quality Standards for Virginia are established and periodically revised by the State Water Control Board. Standards have been adopted for the surface waters and the ground water within the state. Standards are set by stream segments. The standards are based on the designated uses of each segment and the specific criteria needed to protect that usage. Some areas within any segment may be designated for more restrictive uses, such as public water supplies, shellfish waters, or trout waters.

Numerical standards have been adopted for broad classifications of state waters based on intended uses and the geographical regime of the state. These include dissolved oxygen, pH, and temperature. Additional standards for color, metals, organic compounds, nitrogen, and phosphorus have not been established for the entire state.

Special (nitrogen and phosphorus) standards have been set for the tidal embayments of the Potomac River, in the Washington, DC area, the Chickahominy River, and the Lynnhaven River. The standards necessitate enhanced effluent quality.

NPDES Permit Program--

Industrial treatment facilities, publicly-owned treatment works (POTWs), and privately-owned treatment facilities are controlled by the NPDES permit program administered by the State Water Control Board. All discharges into state waters from discrete sources are subject to regulation by this program.

Industrial dischargers must comply with the appropriate best practicable control technology. Sewage treatment facilities must be consistent with the basin-wide and the area-wide waste management plans. All new POTWs must be designed in compliance with the state's sewage regulations. The State Department of Health reviews and approves the plans for treatment facilities.

All facilities must submit monthly reports describing effluent quality to the State Water Control Board. Additionally, the State regularly conducts compliance monitoring surveys of the permitted facilities.

Individual Waste Treatment Facilities--

Approval of septic systems or alternate means of treating wastes from individual households in the responsibility of the State Department of Health. This program is administered through local health departments.

Construction Grants Program--

The State Water Control Board manages the allocation of Federal grant funds for the planning and construction of POTWs. To be funded, a proposed facility must be consistent with the area-wide waste management plan and must be able to meet water quality standards.

A priority listing of projects to be funded is adopted by the State Water Control Board. The list is developed by the staff on the basis of such factors as: public health impacts, severity of effect on water quality, population served, and the need to preserve existing high quality waters. The staff prepares a draft list for each funding biennium. The list is adopted by the Board after a public hearing has been held to receive additional comments.

Pretreatment--

The State Water Control Board has been unable to implement a pretreatment program in Virginia due to manpower and funding constraints. The agency has identified 27 POTWs requiring pretreatment and has developed a check list to assist the localities in ensuring that local sewer ordinances contain the necessary elements for an enforceable program. The agency is now modifying the permits of the identified facilities to include a schedule of compliance for development of a pre-treatment program.

No-Discharge Permit Program--

The State Water Control Board administers a no-discharge permit program for industrial and animal waste treatment facilities. This program regulates activities which can be operated in a manner which does not require a point source discharge. The goals of this program are achieved by the reuse or recovery of wastewater and waste products.

Erosion and Sedimentation Control Programs--

The abatement of erosion and sedimentation (E & S) from construction activities is the ultimate responsibility of the Soil and Water Conservation Commission. Counties and cities have the prerogative of adopting and enforcing the State Erosion and Sedimentation Control Standards or developing their own, which must be at least as restrictive. The Commission must approve E & S plans for construction projects which involve several local governing bodies. The Commission also periodically must review and approve the E & S Handbook for the Department of Highways and Transportation. The State Water Control Board investigates reports of sedimentation in state waters and works with the appropriate agency to correct the problem.

Agricultural Runoff Management--

Under the Area-wide Water Quality Management Program (208), the State Water Control Board has endeavored to abate the pollutant loading from nonpoint sources. Together with many other state and Federal agencies, the SWCB developed best management practices for controlling pollution from certain sources and has identified critical watersheds due to nonpoint source activities. These practices rely on voluntary compliance. For the control of agricultural runoff, the local Soil and Water Conservation District is the governmental body normally involved. Section 3 of this appendix includes additional information on agricultural, as well as, other nonpoint source problems in Virginia.

Urban Runoff Management--
On a state-wide basis, the abatement of pollution from urban runoff is based on voluntary compliance with best management practices. Compliance with statutory requirements or regular maintenance practices to control urban runoff pollution is the option of the individual localities. The effectiveness of this voluntary program is reviewed by the State Water Control Board.

Surface Mining--
The Division of Mined Land Reclamation (DMLR) is responsible for administering the State Strip Mining Regulations and for reclaiming orphan land. The DMLR is in the process of obtaining responsiblity for issuance of NPDES permits for the coal mine discharges.

Dredging, Filling, and Dredged Material Placement--
The U.S. Army Corps of Engineers permits are necessary to perform any activity which can result in a spoil discharge into navigable waters or any dredging or filling in wetlands contiguous to navigable waters.

The State and the Norfolk District and the Baltimore District of the Corps of Engineers utilize the same permit application form. This single booklet serves as an application for the Corps permit, the Marine Resources Commission (MRC) permit, the Wetlands Board Permit, and the State Water Control Board's Water Quality Certification.

The Marine Resources Commission has jurisdiction over all state-owned subaqueous bottom. Any activity which involves the dredging, filling, or crossing of the submerged bottom requires a permit from the MRC. Construction activities which similarly impact subaqueous bottom requires a permit. The Commission charges a royalty for the use of the public resource. The permit may contain stipulations to minimize any adverse impacts.

The Virginia Wetland Act is primarily administered by local (county or city) Wetlands Boards in the tidewater portion of the State. The Wetlands Board permits must be obtained before the Corps of Engineers may act on a proposal. The Marine Resources Commission administers the Wetlands Act in those localities which have not assumed jurisdiction under the Wetlands Act. The MRC also reviews all actions of local boards. Additionally, the MRC is the appeals forum for persons aggrieved by the decision of a local board.

Shoreline Stabilization --
Shoreline stabilization projects are generally subject to the same regulatory statutes and review as the dredging and filling activites. Private land owners often wish to attempt to arrest the erosion of their property; the purpose of the Regulatory Review is to ensure that this protection is obtained in a manner which minimizes the impact on the public resources of the marine environment. The Virginia Soil and Water Conservation Commission has established the Shoreline Erosion Advisory Service (SEAS) to advise property owners regarding shoreline stabilization.

The Commission on the Conservation and Development of Public Beaches was authorized by the legislature in 1980. The Commission was established to preserve and enhance the public beaches within the state by administering the Public Beach Assistance and Development Funds. This funding is provided to the localities by the state for restoration of publicly-owned beaches.

Oil Spills--

State law forbids the discharge of oil or petroleum products into state waters and provides for recovery of investigation costs and damages. An oil-spill contingency fund has been established to facilitate immediate clean-up action for spills when the source or responsible party is undetermined.

Shellfish Sanitation--

The State Department of Health's Bureau of Shellfish Sanitation is responsible for establishing the regulatory standards for Shellfish Sanitation Control. The Bureau regularly samples shellfish growing areas to determine their suitability from a public health perspective. Any growing area which is determined to be unsafe is closed for the direct marketing of shellfish. The State Department of Health regulates on-shore sanitation facilities and sewage pump-out facilities at marinas.

Boat pollution is addressed by Regulation 5 of the State Water Control Board. The state is presently seeking a No-Discharge Zone designation from the Environmental Protection Agency for the Rappahannock River. If this designation is authorized, the state may either require holding tanks for sanitary wastes aboard pleasure craft in those waters or may restrict the area where sewage may be discharged overboard.

Hazardous Wastes--

The State Water Control Board regulates the discharge of toxic materials with the NPDES system. The Board adopted a Toxic Monitoring Program in 1979 which is designed to ensure that industrial dischargers develop site-specific plans to monitor for toxic materials.

The State Department of Health, Division of Solid and Hazardous Waste Management, is responsible for the development of regulatory policy for all aspects of solid and hazardous waste management. This division is involved in the manufacture, transportation, storage, treatment, and disposal of toxic material. Also within the SDH, the Division of Health Hazards Control, Bureau of Toxic Substances Information, collects and stores information regarding the utilization and storage of toxic materials.

The Health Department and the State Water Control Board share some responsibilities under the Resource Conservation and Recovery Act. Both agencies are involved to some degree in the approval of disposal sites. The Health Department regulates the disposal of materials, while the SWCB is responsible for the protection of surface waters and ground-water.

Area-wide Waste Management--

The State Water Control Board has over-all responsibility for administering the Water Quality Management Program pursuant to Section 208 of the Clean Water Act. Seven areas determined to have major water quality problems were designated to develop plans in 1974. The SWCB has the responsibility for developing a 208 Plan for the remainder of the state. The agency has reacted to that mission by compiling best management practices handbooks to develop methods for reducing nonpoint source pollution.

## Resources Management Activities

### Fisheries--

The Marine Resources Commission is primarily responsible for the preservation and enhancement of fisheries (shellfish and finfish) for commercial use. The MRC develops and/or administers the regulations and statutes necessary to protect the fisheries resources. The Commission achieves this goal through the licensing of commercial fishing vessels and fishermen, and by regulating activities in the subaqueous beds in the state. The agency collects and evaluates commercial landings data to determine the status of the resource. The Commission manages the Oyster Rock Repletion Program for 240,000 acres of public oyster grounds. An additional 100,000 acres of state-owned bottom is leased to private shellfish growers.

### Wetlands--

A State Wetlands Act was adopted in 1972 with the declared policy to "preserve the wetlands and to prevent their despoilation and destruction and to accommodate necessary economic development in a manner consistent with wetlands preservation." Vegetated tidal-wetlands are considered to be any area containing specific vegetation species which are located between and contiguous to mean low-water and on land situated within an elevation of 1.5 times the mean tide-range above the mean low-water. The Wetlands Act authorized tidewater localitites to establish Wetlands Boards to regulate activities which affect wetlands. All decisions of the Wetlands Boards are subject to review by the Marine Resources Commission. Any case decision by a Wetlands Board may be appealed to the Commission. The Wetlands Boards depend heavily on the Virginia Institute of Marine Science for technical advice and support.

The 1972 Act has now been amended by the 1982 General Assembly to include all non-vegetated areas of the shoreline between mean low and mean high-water. All unexempted activity in this new area became subject to regulation on January 1, 1983.

### Coastal Resources--

The coastal region of Virginia contains sixty percent of the state's population. The Port of Hampton Roads is vital to the economy and the defense of the entire country. The Chesapeake Bay is the nation's greatest and most productive estuary. This blend of people, economy, and resources makes prudent management of the coastal resources imperative.

Development and growth is carefully managed to ensure that the land uses are compatible. In Virginia, this function is normally handled by the local governing bodies through the Zoning and Land Use Planning Sections. The State Wetlands Act is a state law that has land-use regulation overtones.

The fisheries resources (shellfish and finfish) are managed by the Marine Resources Commission. The Commission also has general regulatory responsiblilities for all submerged lands, tidal wetlands, and primary coastal sand dunes.

The State Department of Health is mandated to ensure the public health. In the coastal areas, the evaluation of the shellfish beds is a critical function of this agency. Individual waste-treatment facilities are also regulated by the Health Department.

The State Water Control Board has permit programs to regulate discharges from sewage and industrial waste-treatment facilities and to control agricultural animal waste discharges. The agency has the responsibility for investigating and, if necessary, cleaning up oil spills within the state. The SWCB also has a Water Quality Certification Program to evaluate the water quality impacts of projects which require Army Corps of Engineers Permits.

The Council on the Environment administers a biennial review of coastal resources management activities in Virginia. The state's success at achieving its coastal resource management goals are evaluated carefully through this process. The report contains specific recommendations to achieve the state's basic goals.

Several state agencies are involved in industrial and economic development. The Virginia Port Authority operates several port facilities in Hampton Roads and generally promotes the use of Virginia ports for international shipping. The Division of Industrial Development is responsible for attracting industry for Virginia and assists industries in selecting suitable locations. The Marine Resources Commission regulates both the fisheries resource and the fisheries industry.

Wildlife--

The protection and regulation of wildlife and the non-marine fisheries in Virginia is the purview of the Commission of Game and Inland Fisheries (CGIF). The CGIF achieves this goal through licensing and enforcement procedures and through wildlife management activities. The Commission owns and manages seven tracts of land in Tidewater Virginia, totalling over 25,000 acres. The CGIF also serves sportfishermen and recreational boaters by providing free boating access to state waters. Over 50 public boat landings are operational in the coastal area.

## SECTION 3

# NONPOINT SOURCE WATER POLLUTION PROBLEM AREAS AND ON-GOING WATER QUALITY MANAGEMENT PROJECTS IN CHESAPEAKE BAY REGION, BY STATE

The Water Quality Management Planning Programs carried out by the states during the last few years (FY 80 to FY 81) focused on nonpoint source (NPS) water quality problems. States conducted assessments for NPS categories perceived to be of most importance in terms of water quality impacts and control feasibility. In many cases, the assessments resulted in the identification of priority areas where problem solving implementation programs should be initiated or accelerated. This document is a summary of the identified priority NPS problem areas for each state and of the abatement programs presently being implemented.

Several informational sources were utilized in the development of the maps and tables contained in this report. Generally, specific NPS problem areas were identified from the state-wide assessments conducted through Section 208 and the Clean Lakes Programs. Solution development and implementation were also addressed by those programs, and all of the states in EPA's Region III have adopted plans that cover some of the more critical NPS categorical problems. In addition, the implementation programs of the USDA are included. Table 7 summarizes the informational sources.

This appendix does not present a comprehensive and thorough identification and ranking of NPS problems either within or among the areas in Region III. The main purpose of this report is to provide a summary of the critical NPS problems and solutions associated with the EPA supported EQM progams in the states. Therefore, the information in the tables and maps focuses on agricultural problems; a few other types of problems are addressed to varying degrees. The reader must recognize that a) for some NPS problems, the state's assessments have not yet progressed to the point of critical problem identification (i.e., ground water problems and toxics), and b) some problems are very extensive and difficult to solve due to economic considerations (i.e., abandoned mine problems).

TABLE 7. INFORMATION SOURCES FOR NONPOINT SOURCE MAPS AND TABLES

| Information Source | Delaware | Maryland | Pennsylvania | Virginia | West Virginia |
|---|---|---|---|---|---|
| Agriculture Water Quality Management Plan | Identified 1 watershed ranked by New Castle County. | Identified all 12 watersheds by State Committee ranking. | Identified only top 10 watersheds of the 21 listed by State Committee. | Identified all 15 watersheds by State Committee ranking. | Identified all 5 watersheds by State Committee ranking. |
| Clean Lakes Projects | Identified the one project. | Identified the 3 projects. | Identified 1 of 2 lake projects. | Identified 3 of 3 lake projects. | None |
| Survey & Classification of Statewide Lakes | Identified 3 top priority areas. | None | Identified 3 top priority areas. | Identified 2 top priority areas. | None |
| Soil Conservation Service Res. Cons. and Dev. Project | None, * | None, * | 1 project documented | None, * | None, * |
| Soil Conservation Service Flood Protect. & Watershed Protect. Prog. | None, * | 3 projects identified. | 1 project identified. | None, * | 1 project identified. |
| Agric. Stab. & Conser. Serv. Ag. Conser. Prog. | None, * | 3 projects identified. | 5 projects identified. | None, * | 3 projects identified. |

(continued)

TABLE 7. continued.

| Information Source | Delaware | Maryland | Pennsylvania | Virginia | West Virginia |
|---|---|---|---|---|---|
| Agric. Stab. & Conser. Serv. Rural Clean Water Prog. | 1 project identified. | 1 project identified. | 1 project identified. | 1 project identified. | None, * |
| 208 Funded Prototype Projects | 4 significant projects identified. | 4 significant projects identified. | 9 significant projects identified. | 1 significant project identified. | 1 significant project identified. |
| Silviculture Water Quality Management Plan | None, + | None, + | None, + | 3 areas identified which have initiated Best Management Practice studies. | 2 areas identified. identified. |
| Construction Water Quality Management Plan | None, + | None, + | 2 areas identified as part of other nonpoint source problems. | None, + | 1 area identified. |
| Mine Drainage Affected Watersheds | None. | None identified. [305(b) report shows many problem areas.] | None identified. [305(b) report shows many problem areas.] | None identified. [305(b) report shows many problem areas.] | Identified top 10 from ranking of mine drainage affected watersheds. |
| National Urban Runoff Program | None. | 2 projects identified. | None. | None. | None. |

[*] No other USDA projects in state identified Agricultural water quality problem-area.

[+] No significant state-wide assessment initiated to date.

TABLE 8. NONPOINT SOURCE PROBLEM AREAS IN MARYLAND AND THE DISTRICT OF COLUMBIA

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 1 | Double Pipe Creek Watershed | Agriculture | State-wide Plan for Agriculture | 89% Agricultural land use, suffers from excessive sedimentation & high fecal bacteria counts. | Rural Clean Water Program ($ Million) and 308 Monitoring Evaluation Support Program |
| 2 | Lower & Upper Monocacy Watershed | Agriculture | State-wide Plan for Agriculture | 66% agricultural land use, high levels of coliform bacteria and large suspended solids loads. The Monocacy drains agricultural, dairy, and cattle farms & the sediment load contributed by the Monocacy to the Potomac has been estimated to be as high as 25% of the total load. | 208 Monocacy Watershed NPS Loading Study & Glade Creek Tributary of Monocacy Agricultural Conservation Program |
| 3 | Liberty Reservoir | Agriculture | State-wide Plan for Agriculture | 61% agricultural land use, water quality standards are being met with the exception of bacteria levels. | Liberty Reservoir Agricultura Conservation Program |
| 4 | Loch Raven Reservoir | Agriculture | State-wide Plan for Agriculture | 48% agricultural land use, occassionaly water quality standrads not met for bacteria. | Clean Lakes Project (Phase II and Wasteload Allocation Stud |
| 5 | South Branch Patapsco Watershed | Agriculture | State-wide Plan for Agriculture | 24% agricultural land use, Water Quality Standards for bacteria are occasionally in violation. | Piney Run Tributary of South Branch of Patapsco River Completed Flood Protection & Watershed Protection Program |
| 6 | Seneca Creek Watershed | Agriculture | State-wide Plan for Agriculture | 68% agricultural land use, bacteriological levels continue to be higher than background. | Seneca Creek Flood Protection & Watershed Protection Progra |
| 7 | Prettyboy Reservoir | Agriculture | State-wide Plan for Agriculture | 57% agricultural land use. Water Quality standards for bacteria are occasionally violaged. | Waste-load Allocation Study |

(continued)

TABLE 8. (continued)

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 8 | Potomac Watershed Frederick County | Agriculture | State-wide Plan for Agriculture | Definite runoff identified as an ongoing pollutant. The effects of nonpoint source pollutants are now more obvious. The major pollution problem in the Maryland portion of the Potomac River Basin is now recognized as surface runoff and soil erosion. | |
| 9 | Potomac Watershed Montgomery County | Agriculture | State-wide Plan for Agriculture | Runoff definitely identified as an ongoing problem. | Completed Flood Protection & Watershed Protection Program on Upper Rock Creek Watershed |
| 10 | Little Gunpowder Falls | Agriculture | State-wide Plan for Agriculture | 54% agricultural land use. Bacteria is a major problem in the Little Gunpowder Falls area. | |
| 11 | West River | Agriculture | State-wide Plan for Agriculture | 35% agricultural land use. Water Quality standards are being met with the exception of high bacteria levels. | |
| 12 | Lower Elk River | Agriculture | State-wide Plan for Agriculture | 47.6% agricultural land use. Water Quality standards are being met with the exception of bacteria violations betwen Frenchtown Wharf and Turkey Point. | |
| 13 | Lake Roland | Unidentified | Clean Lakes Program | Since its creation, there has been rapid reduction in volume & surface area due to sedimentation. In addition to the loss in capacity and surface area of the lake, the sedimentation has adversely impacted water quality of the lake and its tributary streams. | Clean Lakes Project (Phase 1) |

(continued)

TABLE 8. (continued)

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 14 | Columbia Lakes | Residential & commercial runoff | Clean Lakes Program | Chronic oxygen deficienty during the summer is the single greates problem in Wilde Lake. In Lake Kittamagundi, the single greatest problem is the very excessive sediment and nutrient loadings from the Little Patuxent River. Based on the size of the watershed (2000 acres) & the amount of land which is expected to develop in the next ten years (1000 acres), Lake Elkhorn has the highest potential for environmental degradation of any of the three lakes. | |
| 15 | Antitam Creek Watershed | On-lot | State Water Quality Management Plan | 69% agricultural land use. Bacterial pollution and large suspended solids loads contribute substantially to restrictions on aquatic life. Found in USGS 1976 survey Antietam Creek had highest concentrations of metals, insecticides, and PCBs in the Potomac Basin. Highfield-Cascade & Boonsboro, Sharpsburg, & Keedysville areas are being evaluated for alternatives to alleviate failing septic systems. | Washington County Ground-water Management 208 Program |
| 16 | Jones Falls Watershed | Urban runoff | Regional Planning Council Water | 78% developed land use. Water Quality Standards are generally being met with the exception of bacteria and pH standards violations during dry weather. | Jones Falls National Urban Runoff Program |
| 17 | Patuxent River | Unidentified | State Water Quality Management Plan | Portions of the river show signs of water quality stress in terms of dissolved oxygen and bacteria. Low dissolved oxygen is a problem in the lower mainstem portion of the river. In the middle section of the river, bacteria and low dissolved oxygen are problems. The Piedmont portion of the basin (headwaters region) has good water quality. | Wasteload Allocation Study & Agricultural Conservation Programs (Howard, Montgomery Prince Georges, and Calvert Counties) |

(continued)

TABLE 8. (continued)

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 18 | Maryland Shore | Unidentified | State Water Quality Management Plan | The upper Wicomico River & the area near Salisbury experience violations of the Class I bacterial standards. Lower portion of Wicomico River closed to shellfish harvesting. The Nanticoke River exhibits low dissolved oxygen levels. Bacterial levels higher than background have been observed in some areas of the Upper Choptank. | Eastern Shore Nitrate Contamination Control 208 Project |
| 19 | Washington, DC, Urban Area | Urban runoff | Washington Council of Governments Water Quality Management | During summer, near-anaerobic conditions exist in the stratified bottom layer of water. Storm-induced discharges of combined sewer over-flows and urban runoff will continue to burden the Potomac estuary with high sediment and fecal coliform levels. | Washington Council of Governments National Urban Runoff Program |
| 20 | Little North-east Creek | Agriculture | State Water Quality Management Plan | 49% agricultural land use. Problems with high bacterial counts. | |

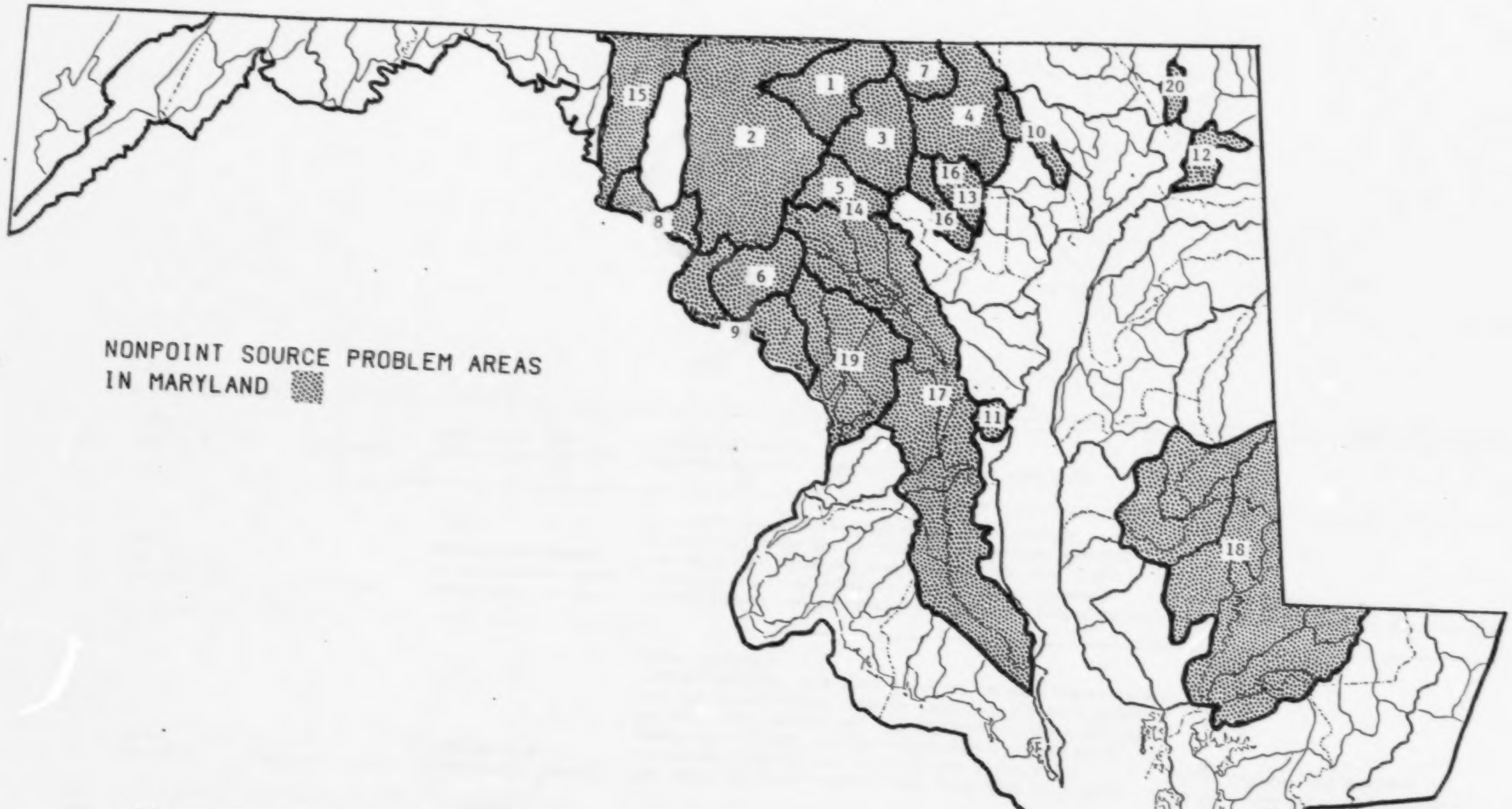


Figure 9. Location of nonpoint source problem areas in Maryland

TABLE 9. SUMMARY OF MARYLAND AND THE DISTRICT OF COLUMBIA NONPOINT SOURCE PROJECTS

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Monocacy Watershed Nonpoint Source Loading Study -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. A nonpoint source and land-use loading analysis will be conducted in this project. The establishment of loading rates for various land-use types will be done (Carroll, Frederick Counties).

Cooperative Extension Service -- Water Quality Specialist -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. This project provides for an extension specialist to serve as a liaison between water quality management programs and the agricultural comminity. Agricultural nonpoint source planning is done as well as varied public information tasks (Carroll County, State-wide).

Rural Clean Water Program Monitoring and Evaluation -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. Project supports monitoring activities being done at the Carroll County Double Pipe Creek USDA Rural Clean Water Program (RCWP) location. Monitoring will show and determine impacts of BMPs installed at the RCWP project area (Carroll County).

Eastern Shore Nitrate Contamination Control Project -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. Ground-water contamination from nitrate will be investigated and sources will be identified. An assessment of the effectiveness of BMPs to reduce contamination will be done (Dorchester, Wicomico, Caroline Counties).

State-wide Agriculture Water Quality Management Program for the Control of Sediment and Animal Wastes -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. A plan was developed on state-wide sediment and animal waste problems and contains three elements. The first is a methodology for assessing critical areas. The second element details recommended BMPs. The third element details a process for the development of individual farm soil conservation and water quality plans (State-wide).

Project Clear Water -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. A major conservation renovation of a farm was conducted as a pilot demonstration project showing the impacts of BMPs on water quality (Frederick County).

Patuxent Nonpoint Source Generation and Delivery Model -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. This project will result in the development of a model that will simulate the generation of selected nonpoint source pollutants in the Patuxent watershed and the delivery of those pollutants to the Patuxent estuary (Patuxent Basin Counties).

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(continued)

TABLE 9. (Continued)

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Establishment of Maryland Agricultural Cost-Share Program -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. This task will provide start-up services for the newly enacted Maryland Agricultural Cost-Share Program. Regulations, field manuals, information brochures, and other administrative products will be developed (state-wide).

Baltimore Metropolitan Region Water Quality Management Plans of Work (On-lot Disposal Problem Assessment, Ground Water Management Program, and Stormwater Management Plan) -- Dr. Philip S. Clayton, Baltimore Regional Planning Council, 301-383-5826.

a. On-Lot Disposal Problem Assessment -- This project is to analyze septic system usage, identify on-lot problem areas, review management administration and report on on-lot disposal alternatives.

b. Ground-Water Management Program -- Program will review existing ground-water data, assess land-use ground water relationships, identification of ground water problem areas, and develop recommendations to minimize ground-water problems.

c. Stormwater Management Plan -- Project is to assess BMPs in developing areas for their effectiveness, analyze current institutional mechanisms, coordinate efforts with the Jones Falls NURP Project, and evaluate management programs.

As part of the Nation-wide Urban Runoff Program (NURP), the Regional Planning Council is also involved in a project to determine the impacts of urban runoff on water courses in the Baltimore metropolitan area.

Northeast Creek Nonpoint Source Monitoring -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. Monitoring has been done in conjunction with an Agricultural Conservation Program in the Northeast Creek Watershed.

Hazardous Waste Facilities Development and Siting Program -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. Program will predict future demand on waste facilities in Maryland, research alternative disposal options, and prepare list of candidate facility sites. One or more selected alternatives will be looked at pertaining to its preliminary engineering and operating budgets.

Washington County Ground Water Management Program -- Peter Tinsley, Maryland Department of Health and Mental Hygiene, Office of Environmental Programs, 301-383-4214. Project will assess the causes of ground water contamination; a management program will be developed based on this assessment.

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(continued)

TABLE 9.

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District of Columbia Council of Governments

Metropolitan Washington Council of Governments 208 Water Resources Planning Program -- Austin Librach, Director, Council of Government's Department of Environmental Programs, 202-223-6800. The Council of Government's work includes tasks under the 04 and 05 grants.

The 04 grant included two watershed nonpoint source management studies -- one on Seneca Creek in Montgomery County and one on Piscataway Creek in Prince George's County.

The 05 grant, as part of the Region's Potomac Strategy, is going to evaluate the relationship of nonpoint source loads to point source loads in the Wasteload allocation setting process.

As part of the Nation-wide Urban Runoff Program (NURP), the Council of Governments is also involved in a project to determine the impacts of urban runoff on water courses in the Washington, DC metropolitan area.

TABLE 10. NONPOINT SOURCE PROBLEM AREAS IN PENNSYLVANIA

| Map Area | Location | Non Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 1 | Conestoga Creek Watershed & Mill Creek Watershed | Agriculture | Statewide Plan For Agriculture & Wasteload Allocation Study | Cocalico Creek has non-point source problems resulting from erosion & sedimentation and three miles of the stream is degraded by non-point source problems. Mill Creek has non-point source agricultural runoff with two miles of the stream degraded by non-point source problems. | Rural Clean Water Program ($1.93 Million) and 208 Study-Effects of Agricultural BMPs on Conestoga River. |
| *2 | Upper Middle Schuylkill River Watershed & Tulpehocken Creek | Agriculture | Statewide Plan for Agriculture and 305(b) report | Agricultural runoff is responsible for dissolved oxygen and nutrient problems of Telpehocken Creek & thirty miles of the stream are degraded by non-point source problems. Residual effects of abandoned acid mine drainage and runoff adversely affect water quality of the Schuylkill River and twenty-one miles of this river are degraded by non-point source problems. | Furnace Creek Tributary of Tulpehocken Creek Agricultural Conservation Program. |
| 3 | Potomac Basin Watershed from Green Ridge to State Boundary | Agriculture | Statewide Plan for Agriculture | There is lake eutrophication due to waterfowl concentration and one half mile of Middle Creek degraded by non-point source problems. | Rock Creek tributary of Potomac Basin Agricultural Conservation Program |
| | | Agriculture | Statewide Plan For Agriculture | | |

TABLE 10. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 5 | Staman's Run Watershed & Chickies Creek Watershed | Agriculture | Statewide Plan for Agriculture & 305(b) Report | Non-point source problems in Chickies Creek resulting from manure runoff & agricultural erosion and sedimentation. Ten miles of this stream degraded by non-point source problems. | Chickies Creek Agricultural Conservation Program |
| 6 | Elk Creek Watershed & Northeast Creek Watershed | Agriculture | Statewide Plan for Agriculture | | |
| 7 | Codorus Creek Watershed & Pinchot Lake Watershed | Agriculture | Statewide Plan for Agriculture | Two miles of Codorus Creek is degraded by non-point source problems. | |
| *8 | Red & White Clay Creeks of the Christiana River Watershed | Agriculture | Statewide Plan for Agriculture | Major fishkills attributed to composting from the mushroom growing industry. | 208 study underway to develop and induce implementation of BMPs. |
| 9 | Shenango River & Pymatuning & Shenango Reservoirs | Agriculture | Statewide Plan for Agriculture | Shenango River's taste & odor problems are due in part to non-point sources of pollution (migratory waterfowl, swamps, agriculture). | Flood Protection and Watershed Protection Program & Shenango Agricultural Conservation Program. |

(Continued)

TABLE 10. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 10 | Perkiomen Creek Watershed | Agriculture | Statewide Plan for Agriculture | Oxygen consuming & nutrient problems due in part to non-point source problems & sixteen miles of the stream are degraded because of non-point source problems. | |
| *11 | Lake Wallenpaupak | Agriculture, On-Lot, Urban Runoff | Phase I, Clean Lakes Study | Water Quality problems due to sewage from malfunctioning on-lot systems around the lake and from non-point waste sources. | Clean Lakes Program |
| *12 | Edinboro Lake | Agriculture & Urban Runoff | 1981 Draft-EPA EIS Project 675 Edinboro & Washington Township & ranks 1st in statewide priority | Water quality degradation is due to agricultural runoff & siltation from other non-point sources. | An Agricultural Conservation Project and a Resource Conservation & Development Project |
| 13 | Sugar Creek Watershed & Towanda Creek Watershed & Wyalusing Creek Watershed | Agriculture | 305(b) report | Sugar Creek has localized water quality problems due in part to farmland runoff & thirty-four miles of this stream are degraded by non-point source problems. Towanda Creek has some sections affected by farmland runoff and eight miles of this stream are degraded by non-point source problems. Wyalusing Creek has farmland runoff problems in its agricultural sections & twenty-two miles of the stream are degraded by non-point source problems. | |

(Continued)

TABLE 10. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 14 | Conodoquinet Creek Watershed | Agriculture | 305(b) Report | Phosphorus problems due to agricultural runoff in part. Nine miles of this stream are degraded by non-point source problems. | Agricultural Conservation Program at Upper Frankford Township on Conodoquinet Watershed |
| 15 | Penn Creek Watershed | Agriculture | 305(b) Report | Some minor problems due to farmland runoff and nine miles of this stream are degraded by non-point source problems. | |
| 16 | Buffalo Creek Watershed | Agriculture | 305(b) Report | Some water quality problems are due to farmland runoff and six miles of the stream are degraded by non-point source problems. | |
| *17 | Meadville Regional Area | Industrial Non-point source pollution | Pennsylvania Water Quality Management Plan & 305(b) Report | Oil and gas well drilling & production activities have been identified as a major source of non-point pollution in the Northwestern part of the State. | 208 Program - Pennsylvania Oil and Gas Well Pollution Control Project |
| *18 | Schuylkill River (Reading to Fairmount Dam) | Unspecified (All types of toxics) | Pennsylvania Water Quality Management Plan | Determining the distribution & concentration of selected priority pollutants, pesticides, and heavy metals associated with river-bed sediments. | Schuylkill River Sediment Study |
| *19 | Girty's Run Watershed | Urban-Runoff | Pennsylvania Water Quality Management Plan | Project is an initial step toward eventual development & adoption of a Statewide Urban Runoff Non-Point Source Plan. | Girty's Run Stormwater Quality Management Planning Project |

(Continued)

TABLE 10. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 20 | Yellow Breeches Watershed | Urban-Runoff | Pennsylvania Water Quality Management Plan | Project is an initial step toward eventual development & adoption of a Statewide Urban Runoff Non-Point Source Plan. | Yellow Breeches Stormwater Quality Management Planning Project |
| *21 | Northampton & Lehigh Counties | On-Lot | Pennsylvania Water Quality Management Plan | Project will determine through demonstrations how management of on-lot systems can be improved. Results of this project will be incorporated in Statewide plan for on-lot management. | Lehigh-Northampton On-Lot Management District Demonstration Project |
| *22 | Nockamixon Lake (Bucks County) | Agriculture & Urban Runoff | Trophic Classification and Characteristics of Twenty-six Publicly Owned Pennsylvania Lakes | The lake suffers from high nutrient loadings. Excessive algae growth & Hypolimnetic anoxia occurs when the lake is thermally stratified. | |
| 23 | Speedwell Forge Lake (Lancaster County) | Agriculture | Trophic Classification & Characteristics of Twenty-six Publicly Owned Pennsylvania Lakes | Lake is fertile and supports dense growth of algae and rooted aquatic plants. The lake is severely silted over about one-half of its surface area and contains high levels of inorganic nitrogen. | |

(Continued)

TABLE 10. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| *24 | Green Lane Reservoir (Montgomery County) | Agriculture & Urban Runoff, Construction Activities, & On-Lot | Pennsylvania Water Quality Management Plan | The Reservoir is a major source of public water supply and identified second as most eutrophic body of water in Pennsylvania. | Green Lane Reservoir 208 Project |
| *25 | Carbonate Outcrop Areas (Montgomery, Chester, and Bucks Counties) | Construction Activities & Urban Runoff | Pennsylvania Water Quality Management Plan | | Urban Stormwater/Carbonate BMP's 208 Project |

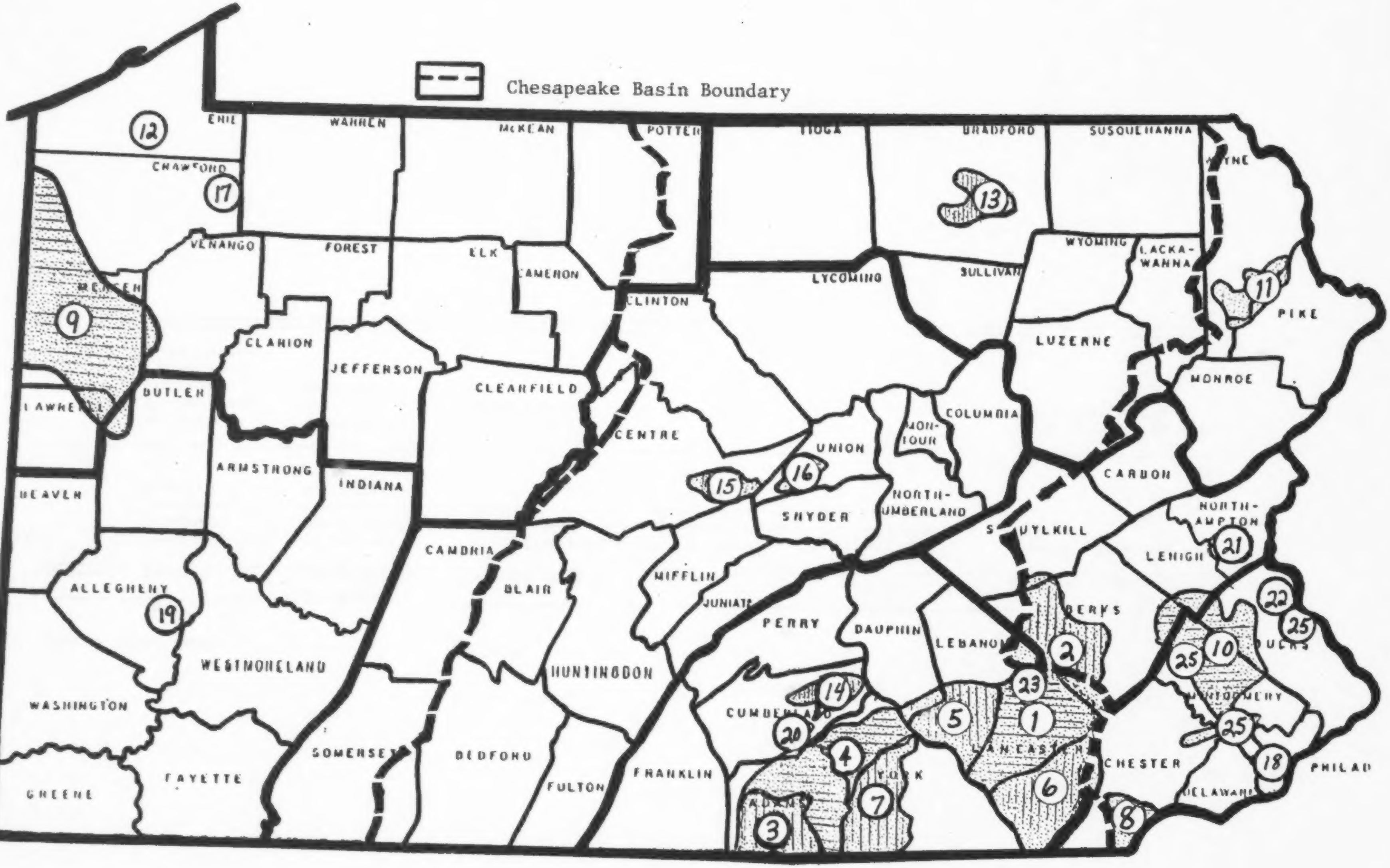

Figure 10. Location of nonpoint source problem areas in Pennsylvania

TABLE 11. SUMMARY OF PENNSYLVANIA NONPOINT SOURCE PROJECTS

Completion and Adoption of a Water Quality Management Plan for the Management of On-lot Disposal Systems -- R. E. Erickson, Division of Sewage Facilities Act Administration, 717-787-9032. To develop an implementable plan for the management of the on-lot sewage disposal program. The plan will describe the existing program, identify deficiencies, make recommendations for their correction, and describe needed resources. The plan will consider: (1) latest technological developments; (2) related study and research recommendations; and (3) institutional constraints.

Accelerated Development of a Nonpoint Source Toxic Substances Management Strategy -- Michael Arnold, Toxic Substances Coordinator, Division of Nonpoint and Industrial Sources, DER Bureau of Water Quality Management, 717-787-8189. To develop a strategy for the management of nonpoint source-related toxic substances.

Accelerated Assessment of Agricultural Pollution in Priority Areas, Including an Educational Program Developed by the Cooperative Extension Service -- Victor Funk, Bureau of Soil and Water Conservation, 717-787-5269. To identify specific nonpoint pollution problems linked to agricultural activities within high-priority watersheds contained in the agricultural portion of Pennsylvania's 208 plan; to develop recommendations for implementation strategies that will produce water quality improvements in critical areas by application of BMPs; to develop an educational program that will be the most appropriate and effective to encourage the use of BMPs by landowner's voluntary cooperation to achieve water quality goals.

Effects of Agricultural Best Management Practices on the Conestoga River Above Lancaster, Pennsylvania -- Arthur C. Miller, Institute of Land and Water Resources, Pennsylvania State University, 814-865-1521. To evaluate the over-all effects of the implementation of agricultural best management practices on surface and ground water quality in the upper Conestoga River (long-term monitoring sites); to evaluate the cost and effectiveness of agricultural BMPs on surface and ground water quality of specific isolated sites (short-term monitoring sites).

Evaluation of Fertilizer Practices -- Victor Funk, Chief, Watershed Branch, 717-783-7010. To determine the current practices employed by farmers to apply commerical fertilizer to cropland in a pilot-study areas, and to determine if modifications to these practices are necessary or if additional techniques must be developed.

State-wide Ground-Water Quality Monitoring Program -- John O. Osgood, Chief, Ground Water Quality Management Unit, 717-787-9633. To develop a state-wide ground water quality monitoring strategy for Pennsylvania to include identification of monitoring techniques, basin evaluation and priorization, location of monitoring of potential monitoring points in high priority basins, and a cost assessment for implementation purposes. The strategy will be applicable for both ground-water quality and availability activities.

(continued)

TABLE 11.

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Development of Ground Water Quality Standards -- John Osgood, Chief, Ground Water Quality Management Unit, 717-787-9637. To develop and recommend a system of water quality standards for the protection of Pennsylvania ground water resources.

Comprehensive Evaluation of Erosion and Sediment Control Program -- Victor Funk, Chief, Watershed Branch, 717-783-7010. To analyze the operating programs currently in place to control erosion in construction activities, agricultural operations, forest land disturbances, mining activities, oil and gas well drilling operations, and road construction and maintenance activities; to determine if improvements are needed in current policies and procedures to achieve greater compliance with sediment control regulations; to determine whether erosion and sediment control plans are properly prepared, adequately reviewed, installed to specification, and BMPs are achieving the expected control of sediment pollution; and to assess the need for a personnel certification program for individuals involved in E & S plan reviews and site inspections.

Water Quality Management Plan for Agriculture and Construction -- Ernest F. Giovannitti, Chief, Division of Non-Point & Industrial Sources, 717-787-8184. A completed comprehensive plan for Agriculture & Construction Runoff nonpoint source pollution control.

TABLE 12. NONPOINT SOURCE PROBLEM-AREAS IN VIRGINIA

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| * 1 | Nottoway River | Agriculture | Statewide nonpoint source assessment | Not known to what extent nonpoint sources contribute to water quality degradation | |
| 2 | Happy Creek | Agriculture | Statewide nonpoint Source assessment | Substantial agricultural runoff contributes to temporary, but high fecal coliform counts | |
| 3 | Passage Creek | Agriculture | Statewide nonpoint source assessment | | |
| 4 | Upper North Fork Shenandoah | Agriculture | Statewide nonpoint source assessment | | |
| 5 | Potomac (Westmoreland County) | Agriculture | Statewide nonpoint source assessment | Receives nonpoint source runoff | |
| 6 | Lower South Fork Shenandoah | Agriculture | Statewide nonpoint Source assessment | | |
| *7 | North Landing River | Agriculture | Statewide nonpoint Source assessment | Nonpoint sources from both agricultural and animal waste holding systems have a significant effect on water quality | |
| 8 | Upper Goose Creek | Agriculture | Statewide nonpoint source assessment | Following storm occurrences, the streams in the area tend to exhibit elevated levels of fecal coliform bacteria & nutrients | |
| 9 | Cedar Run-Kettle Run | Agriculture | Statewide nonpoint source assessment | Recent studies have shown that nonpoint source runoff from the watershed is the major contributor of nutrients & other pollutants which have deleterious impacts in reservoir water quality | |

(Continued)

* Not in Chesapeake Bay Basin

TABLE 12. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| *10 | Northwest River | Agriculture | Statewide nonpoint source assessment | Nonpoint sources from both agricultural and animal waste holding systems have a significant effect on water quality | |
| *11 | Somerton Creek | Agriculture | Statewide nonpoint source assessment | | |
| *12 | Stony Creek | Agriculture, On-lot Urban Runoff | Statewide nonpoint source assessment | Septic tanks commonly fail & the surface runoff contains high concentrations of organics and bacteria | |
| *13 | Assamoosick Swamp | Agriculture | Statewide nonpoint source assessment | | |
| 14 | Opequon Creek | Agriculture | Statewide nonpoint source assessment | A pesticide nonpoint problem exists in the basin | |
| 15 | Christian's Creek | Agriculture | Statewide nonpoint source assessment | | |
| 16 | Lakes Fairfax & Accotink | Unidentified | Clean Lakes Project | | Clean Lakes Program (Phase 1) Diagnostic-Feasibility Study |
| 17 | Lake Chesdin | Agriculture,Forestry | Clean Lakes Project | Lake Chesdin is eutrophic, Nutrient concentrations & populations of blue-green algae are excessively high. Also experiencing rapid sedimentation & filling of the reservoir | Clean Lakes Program (Phase 1) Diagnostic-Feasibility Study and a 208 Project |

(Continued)

TABLE 12. (Continued)

| Map Area | Location | Non-Point Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 18 | Rivanna Reservoir | Unidentified | Clean Lakes Project | Rivanna Reservoir has high blue-green algae concentrations responsible for taste and odor problems. The Reservoir also has excessive sedimentation & oxygen depletion near the bottom of the reservoir. | Clean Lakes Program (Phase II) and a 208 Project |
| 19 | Potomac Embayments of Virginia | Unidentified | Wasteload Allocation Study | Potomac embayments of Virginia described as supporting excess algal populations | 208 Project - Potomac Embayment Assessments Study |
| 20 | Appomattox River-headwaters down to Lake Chesdin Dam | Forestry | Virginia non-point source forestry program | | 208 Project - Implementation of Virginia's Non-Point Source Forestry Program |
| 21 | Slate River | Forestry | Virginia non-point source forestry program | | 208 Project-Implementation of Virginia's non-Point Source Forestry Program |
| * 22 | Sandy River | Forestry | Virginia non-point source forestry program | | 208 Project - Implementation of Virginia's Non-Point Source Forestry Program |
| 23 | Nansemond-Chuckatuck Watershed drainage area | Agriculture | State Coordinating Committee's RCWP Application | | Rural Clean Water Program ($1.89 Million) |

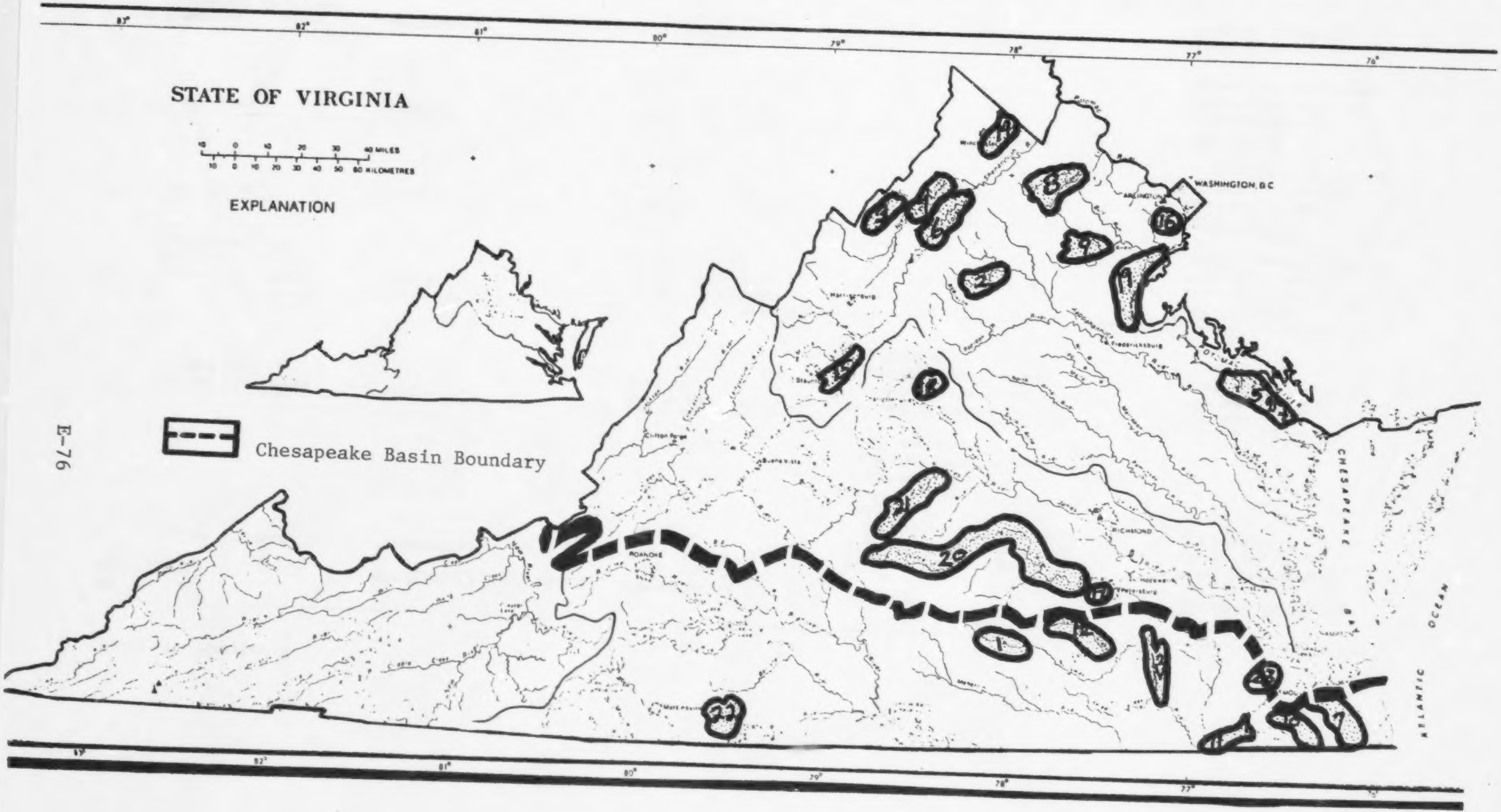

Figure 11. Location of nonpoint source problem areas in Virginia

TABLE 13. SUMMARY OF VIRGINIA NONPOINT SOURCE PROJECTS*

State-wide Nonpoint Source Assessment -- Completed. The Soil Conservation Service has conducted an assessment of potential nonpoint sources of pollution in cooperation with the State Water Control Board. This was done in three phases over a two-year period and was limited to the agricultural and forestry categories of pollution. Phase III map (Figure 11) illustrates watersheds slated for conservation assistance.

South Rivanna Watershed Management Program -- Completed. A Watershed Management Planning program for South Fork Rivanna Reservoir to continue planning and monitoring and to develop a methodology for implementing the County Runoff Control Ordinance (Albemarle County).

Smith Mountain Lake Study -- Completed. The investigation of the impact of nonpoint source discharges on the water quality of Smith Mountain Lake. This is the first investigation of rural nonpoint source discharges under the State of Virginia 208 Water Quality Management Plan Development (Roanoke).

Potomac Embayments Assessment Study -- A re-evaluation of the current embayment standards is being done to plan for the most cost-effective methods of improving the water quality in the embayments.

Economic Evaluation of Impact of BMP Implementation on Agriculture -- Completed. An analysis of economic relationships among agricultural production activities is being done by Virginia Polytechnic Institute and State University. The work included an annual report on economic mathematical programming models, a report on water quality modeling and associated data mangement, and a report on potential for choice and policy strategy for implementing a nonpoint source program with emphasis on local decisions (state-wide).

Agricultural Extension Service Personnel Assistance -- A program to expand and improve the nonpoint source pollution abatement educational program in Virginia, to be conducted by the Virginia Cooperative Extension Service. An Environmental Quality Specialist will assist in the implementation of the agricultural BMP program and provide educational information and render technical assistance in identified critical problem areas of the state.

Implementation of Virginia's NPS Forestry Program -- Efforts will be concentrated in identified critical forestry areas and sites will be checked for erodibility factors and sensitivity of receiving waters. Foresters will ensure that logging operators and timberland owners are aware of and encouraged to utilize BMPs in all phases of their logging operations (state-wide).

Agriculture BMP Implementation Practices -- Monitoring sites will be selected on a critical agricultural watershed of predominately active cropland and the monitoring will consist of gaging streamflow and sampling water quality at several sites in tributary streams. The monitoring is intended to obtain verification data for a hydrologic/water quality model (Montgomery County).

(continued)

TABLE 13.

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Program for Expending and Improving Nonpoint Source Pollution Abatement Educational Programs in Virginia -- A continuation of a project to be conducted by the Virginia Cooperative Extension Service to culminate as part of the implementation phase of the state agricultural nonpoint source control program. Position will provide coordination of various extension programs and agricultural assistance programs with the state nonpoint source program.

Special Nonpoint Source Studies on Chowan River Basin in Conjunction with the State of North Carolina -- The objectives of a two-year Chowan Basin study are: to identify and quantify critical pollutant sources (point and nonpoint) in the upper Chowan Basin; to determine the effect of selected BMP implementation on immediate downstream water quality through analysis of chemical water quality data and limited biological data; and to ensure that the public is aware and involved in the project.

BMP Implementation Strategy at the Local Community and County Level -- A briefing packet was developed for county boards of supervisors and town/city councils to identify BMPs of value to particular communities. The briefing presented methods for enabling the local government to encourage BMP use to get local programs started (state-wide).

Richmond-Crater Consortium Interim Study -- Completed. The program will consist of analyzing point source waste load allocations using a static model, assessing the impact of residual wastes on water quality, a nonpoint source assessment and control needs project, and a public participation program (Richmond and Crater Planning District Commission areas).

Rappahannock Area Development Commission Nonpoint Source Assessment -- Project to assess watersheds and rank them, calibrate a model with sampling data, and do a general assessment the nonpoint source problems (RADCO area).

Hampton Roads Urban Runoff Program -- Project will evaluate BMP effectiveness in four watersheds in Lynnhaven Basin, do BMP testing at construction, high and low density residential, commerical and institutional and industrial land-use sites, and develop BMPs and cost-effectiveness analysis using a stormwater model (Peninsula and Southeastern Virginia Planning District Commission areas).

Roanoke Update for Agriculture, Urban Runoff, and Ground Water Nonpoint Source Categories -- Project description includes: studying of watershed-sized areas, upgrading of malfunctioning septics in the Smith Mountain Lake area, agricultural nonpoint source assessment of dairyland/pastureland and BMP effectiveness study, urban runoff assessment and BMP effectiveness study, ground water strategy identifying problem types for the Roanoke area, and a ground water conservation/public participation program.

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* WQM State Contact: Robert Stapleford, 804-257-6431

TABLE 14. NONPOINT SOURCE PROBLEM AREAS IN WEST VIRGINIA

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 1 | Lower Mill Creek | Agriculture | Agriculture WQM Plan | | |
| 2 | Sandy Creek | Agriculture | Agriculture WQM Plan | | |
| 3 | Upper Mill Creek | Agriculture | Agriculture WQM Plan | | Flood Protection & Watershed Protection Program |
| 4 | Upper Pocatalico River | Agriculture | Agriculture WQM Plan | Repeated standards violations for Total Coliform, Fecal Coliform, & Phenolics. Occasional standards violations for Suspended Solids and Iron. | Agricultural Conservation Program |
| *5 | South Branch River | Agriculture | Agricultural WQM Plan | | Agricultural Conservation Program |
| 6 | Oldtown Creek | Agriculture | Agriculture WQM Plan | | Agricultural Conservation Program and a 208 Project. |
| 7 | Deer Creek | Agriculture | Agriculture WQM Plan | | Agricultural Conservation Program & a 208 Project. |
| 8 | Blackwater River | Acid Mine Drainage | Data Evaluation & Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |
| 9 | Three Forks Creek | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |
| 10 | Gauley River | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | Repeated Standards violations for total coliform and phenolics. Occasional standards viol.for fecal col. | Ongoing Source Evaluation being conducted |
| 11 | Elk Creek | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |
| 12 | Middle Fork River | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |

(Continued)

* Only area in Chesapeake Bay Basin

TABLE 14. (Continued)

| Map Area | Location | Nonpoint Source Category | Documentation | Comments | Abatement Practices |
|---|---|---|---|---|---|
| 13 | Panther Creek | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |
| 14 | Upper Cheat River | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | Occasional Standards Violations for pH, Total Coliform, Phenolics, Iron & Atsenic | Ongoing Source Evaluation being conducted |
| 15 | Tenmile Creek | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watershed Report | | Ongoing Source Evaluation being conducted |
| 16 | Upper Tygart | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | Occasional Standards violations for pH, Total Coliform, Fecal Coliform, and Phenolics | Ongoing Source Evaluation being conducted + Rural Abandoned Mine Program |
| 17 | Meadow River | Acid Mine Drainage | Data Evaluation + Preliminary Ranking of Mine Drainage Affected Watersheds Report | | Ongoing Source Evaluation being conducted |
| 18 | Eastern Allegheny Mountains + Plateaus | Silviculture | Silviculture WQM Plan | | |
| 19 | Central Allegheny Plateau | Silviculture | Silvicuture WQM Plan | | |
| 20 | Little Coal River + Big Coal River | Construction | Construction WQM Plan | Repeated Standards Violations for Total Coliform, Fecal Coliform, and Phenolics | Demonstration Construction Runoff 208 Project for Corridor & Highway |

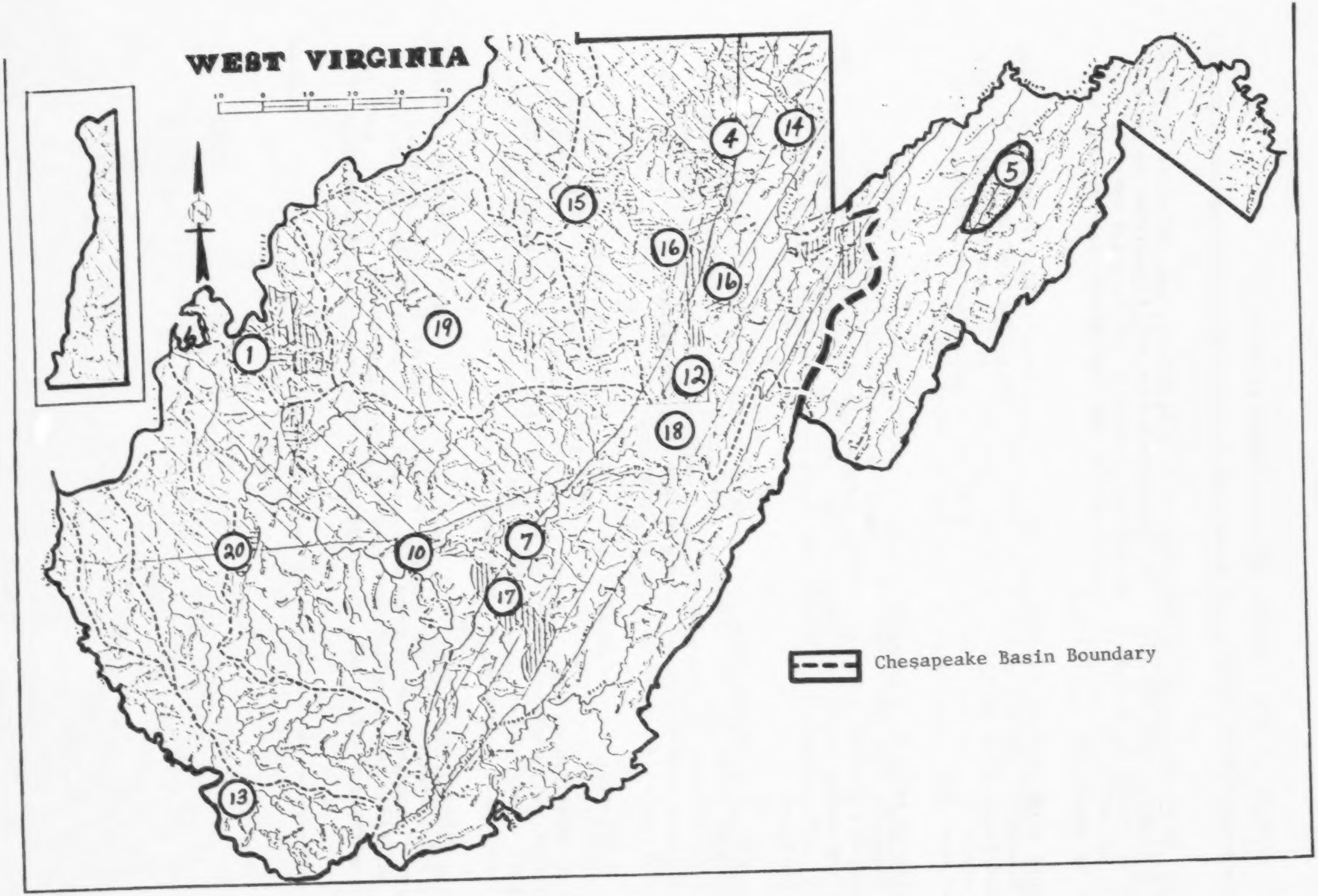

Figure 12. Location of nonpoint source problem areas in West Virginia

TABLE 15. SUMMARY OF WEST VIRGINIA NONPOINT SOURCE PROJECTS

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Agriculture Water Quality Management Plan -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. The agriculture plan would determine nonpoint agricultural pollution sources by watersheds, determine and finalize BMPs for each watershed, establish the priority watersheds for BMP implementation, and develop a program to ensure BMP application.

Silviculture Water Quality Management Plan -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. A voluntary BMP compliance program is to be established based on an expanded educational program. Aerial survey of identifying priority areas to abate silviculture nonpoint scurce pollution is included, along with a proposed demonstration project of BMP implementation.

Construction Water Quality Management Plan -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. This plan includes identification of areas with potential for water quality problems during land-disturbance activities, development of a BMP manual describing practices and listings of general construction activities, and implementation of the plan on a voluntary basis with planned demonstration projects.

Mining Water Quality Management Plan -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. A priority determination of mine-drainage effected watersheds is included in this plan to help ensure the successful implementation of a surface mine reclamation and mine drainage abatement program. Activities are being coordinated with the Division of Reclamation.

Ground Water Strategy Plan -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. It is the intent of the West Virginia Division of Water Resources to establish an overall strategy for the maintenance of ground water at a level that will satisfy current needs and provide for future demands. The strategy will identify those institutional and resource needs necessary to properly implement a ground water management program.

303(e) Basin Plans Update Project -- Douglas Steele, West Virginia Division of Water Resources, 304-348-2108. Project strives to address issues to better identify areas where advanced wastewater treatment appears to be required and identify the potential solutions to particular problems. Work includes stream modeling, sampling, and analyzing water quality, and determining allowable wasteloads to particular watersheds.

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TABLE 16. NONPOINT SOURCE PROBLEM AREAS IN DELAWARE

| Map Area | Location | Nonpoint Source Category | Documentation | Abatement Practices |
|---|---|---|---|---|
| 1 | Appoquinimink Watershed | Agriculture | Volume II New Castle County Areawide Waste Treatment Management Program | RCWP Program & 208 Monitoring & Evaluation Project on Watershed ($7.4 Million) |
| 2 | Smyrna Watershed | Agriculture | New Castle County Agricultural Assessment Ranking Scheme | |
| 3 | Chain of Lakes Watershed (Blairs Pond, Griffith Lake and Haven Lake) | Agriculture | 305(b) Report and Survey and Classification of Delaware's Public Lakes | Clean Lakes Program & 208 Monitoring & Evaluation Project |
| 4 | Lake Como | Agriculture | Survey and Classification of Delaware's Public Lakes | |
| 5 | Lums Pond | Agriculture | Survey and Classification of Delaware's Public Lakes | |
| 6 | Millsboro Area | Agriculture + On-Lot | Sussex County Water Quality Management Plan.Delaware Water Quality Management Plan | 208 Project - Management Plan to Reduce Groundwater Contamination |
| 7 | Frankford-Dagsboro Area | On-lot | Report #8 Case Study Report Rural Wastewater Management | 208 Program - Wastewater Management Plan for Frankford-Dagsboro. |

Note: None of the Delaware problem areas are located in the Chesapeake Bay Basin. However, the RCWP (#1) may be useful to establish BMP effectiveness in reducing nutrient loads wich may be applicable to adjacent Eastern Shore farmland.

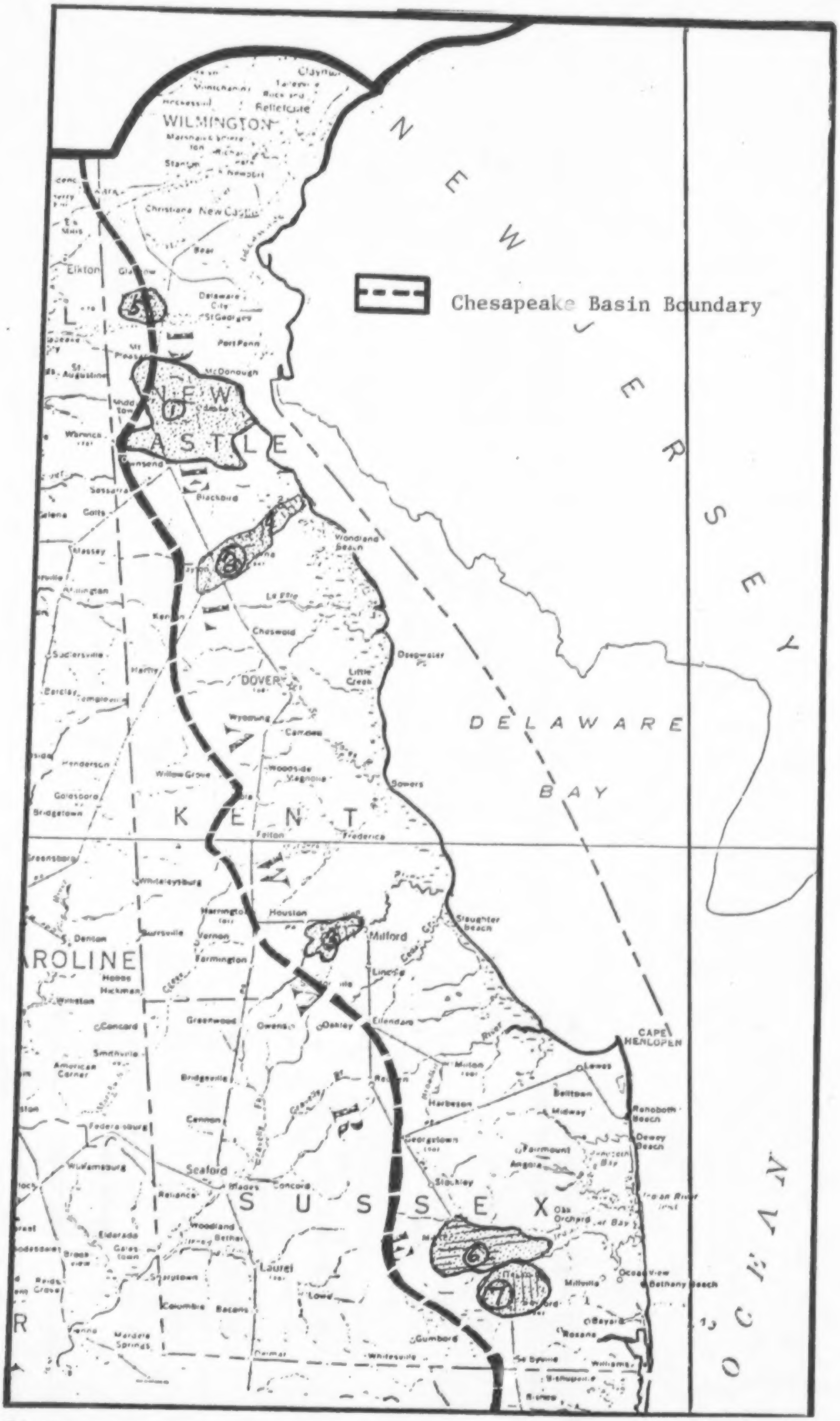

Figure 13. Location of nonpoint source problem areas in Delaware

Table 17. SUMMARY OF DELAWARE NONPOINT SOURCE PROJECTS

New Castle County Water Quality Management Plans of Work (Agricultural, Fiscal and Institutional Management, Ground Water, Mushroom Industry, On-Site Waste Treatment Solid Waste Disposal, and Stormwater Nonpoint Source Control Work Programs -- Bernard L. Dworsky, Administrator, Water Resources Agency for New Castle County, 302-731-7670.

a. Agriculture -- Program to disseminate information to the agriculture and non-agriculture communities regarding the Appoquinimink RCWP project. Transfer of agriculture BMP information will be coordinated by the Water Resources Agency.

b. Fiscal and Institutional Management -- Work plan to examine and analyze existing financing methods and recommend possible alternative sources and mechanisms for the continued funding of the area-wide water quality management program.

c. Ground Water -- Program to establish water quality standards to integrate with the state's ground water management plan, to update agricultural and stormwater best management practices, and to develop an emergency spill response program for New Castle County.

d. Mushroom Industrial Management -- Work plan to rely on voluntary program to implement best management practices with assistance of agricultural conservation district personnel. Plan consists of establishing project oversight committee, quantifying water quality impacts, reviewing monitoring and enforcement programs, and identifying best management practices.

e. On-Site Waste Management -- Program to develop cost-effective guidelines, identify alternative on-site systems for use in ground water recharge areas, develop new regulations and modify old ones, and develop a management program for on-site systems.

f. Solid Waste Disposal -- Work plan to initiate work in furthering the prioritization of landfill sites impacting an area's water quality. Recommendations will be made for a monitoring program on those sites with the highest change of impacting water quality.

g. Stormwater -- Program will summarize fiscal impacts of drainage facilities in New Castle County, participate in the White Clay Creek and City of Newark storm water management projects, and participation in an inter-agency project to develop storm water management controls for the Mill Creek Basin.

# APPENDIX F

# A MONITORING AND RESEARCH STRATEGY TO MEET MANAGEMENT OBJECTIVES

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# FOREWORD

This document is an appendix to the Environmental Protection Agency's Chesapeake Bay Program's report entitled: Chesapeake Bay: A Framework for Action. This monitoring strategy is only one of the management strategies recommended by the Chesapeake Bay Program.

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# EXECUTIVE SUMMARY

Chesapeake Bay remains a highly productive body of water even after centuries of intensive use. Every year it provides millions of pounds of seafood, functions as a major hub for shipping and commerce, supplies natural habitat for over 2,300 species of fish and wildlife, and provides recreation for residents and visitors. In recent years, however, a number of signs have indicated reasons for concern about the state of "health" of the Bay. Serious declines have been seen in freshwater-spawning fish, oyster spat recruitment, and in the abundance of submerged aquatic vegetation (SAV). In addition, indications of degrading water quality exist in the forms of nutrient enrichment, accompanied by blooms of nuisance algae and persistent dissolved oxygen deficiencies, and increasing additions of toxic substances to the water column and sediments.

Monitoring data collected over the years have been adequate for defining trends in water quality and living resources in some areas of the Bay and its tributaries. However, these data have not provided the information needed to understand the meaning of the changes taking place. Apparently, monitoring and research need to be coupled in a mutually reinforcing manner that would help reduce the uncertainty in explaining the meaning of observed changes in the Bay.

The construction of a new Bay-wide monitoring strategy consisted of three major steps. First, the Bay's declining natural resources were described and questions that needed to be answered to determine the precise cause(s) of the decline were posed. Second, the existing state and Federal monitoring programs were mapped. Finally, the strengths and weaknesses of the existing programs were evaluated in light of their ability to answer the questions concerning the living resources.

The evaluation of the current monitoring programs revealed several weaknesses, including:

1) data collection gaps;
2) duplication of effort;
3) the failure to collect water quality and living resource data together;
4) the absence of Bay-wide monitoring goals and objectives; and
5) the lack of support between monitoring and research.

With these weaknesses in mind, the CBP staff set out to formulate a new Bay-wide monitoring strategy. The first step in this process was to define how one uses a monitoring program to solve the Bay's problems. The traditional approach of relying principally upon trend monitoring was abandoned as ineffective. It was necessary to have a procedure that combined monitoring, research, and management. These three elements had to be combined into a continuous interpretive feedback system.

Managers need sound cause-and-effect information to make wise management decisions. Therefore, the collection of environmental data must be done in a manner that minimizes the uncertainty associated with cause-and-effect inferences. The collection of data can be done on a series of levels, each designed to give a different level of confidence in the data. These levels are defined as follows:

Level I: Descriptive -- to allow the monitor to describe statistically changes in the parameters measured over time and make trend assessments.

Level II: Analytical -- to allow the monitor to derive meaningful correlations among several of the parameters measured over time with defined statistical significance.

Level III: Interpretive -- to allow the monitor, analyst, and scientist to determine cause-and-effect relationships among several of the parameters measured over time and to understand and predict, with statistical characterization, interactions among ecosystem components and the probable effects of changes.

The new Bay-wide monitoring strategy was patterned after this hierarchical approach. It presents baseline monitoring activities (i.e., collection of ambient water quality, sediment, and living resources data) done at Level I and Level II efforts. This provides descriptive information and allows the forming of initial hypotheses concerning possible cause-and-effect relationships. The next logical step in this process is to design a Level III (monitoring and research) approach which will lead to the understanding of cause-and-effect relationships and provide a basis for management action. A plan that combines all three levels provides a more effective strategy than the use of any single level approach. Therefore, the new Bay-wide monitoring strategy joins traditional monitoring with research, and places them in a management context.

The master monitoring plan as outlined in this document has several facets:

- it has a Bay-wide perspective;
- it is problem oriented;
- it builds on present monitoring programs;
- it assumes coordination of efforts between state agencies and between state and Federal agencies;
- it emphasizes communication and cooperation between managers and researchers;
- it emphasizes the necessary relationship between baseline (pulse-taking) monitoring, research, and data analysis; and
- it assumes that there will be an effective Bay-wide data management plan.

Because this Bay-wide monitoring program will be a long-term effort carried out over several years, data management is critical and should be a continuing process. This document suggests a data management plan whereby field measurements will be recorded, transcribed, entered into the computer, quality checked, organized into a unified data base, and maintained in a secure, accurate, and efficient manner for subsequent retrieval and analysis.

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# INTRODUCTION

The Chesapeake Bay system (Figure 1) is a national resource recognized for its productivity which is expressed as fishery yields, recreation, and as a water-course providing large volumes of water for industry and transportation. In recent years, a number of signs have indicated reasons for concern about the state of "health" of the Bay (U.S. EPA 1982b, Flemer et al. 1983). To fulfill the information needs of Bay managers, industry, the public, and the research community concerning possible future changes in the Bay, it is essential that an effective monitoring program be developed that builds on present knowledge and monitoring efforts.

An effective monitoring program should have several goals. It should: enhance our ability to understand the difference between natural phenomena and anthropogenic events; provide information about controllable land-use activities that can affect the Bay's ecology; and also provide a framework for research. Monitoring will become inefficient when it is uncoupled from research, (that is, when data are collected and not interpreted).

Monitoring, as it is defined in this document, departs from the more traditional usage of the word and is better phrased as "analytical monitoring." The definition then becomes: a structured approach to environmental measurements in response to a specific question which permits a causal inference to be made. Analytical monitoring requires the coupling of environmental resources, management questions, and scientific research. This leads to a better understanding of environmental variability resulting from both natural and human influences.

Chesapeake Bay is a complex system not only in physical, chemical, and biological components and processes, but also in terms of its "goods and services" that result from numerous ecological processes, including the flow of the sun's energy through the photosynthetic process of plants (including microscopic phytoplankton) to the fisheries and the human uses of the system (U.S. EPA 1982a). As an estuary, the Bay has important gradients and heterogeneities in its geology, physics of water movement, chemistry, and biology. Thus, it is not a homogeneous environment but one of a myriad of dynamic features. The human uses of this complex and diverse system are manifold. Based on these observations, it would appear that a monitoring program would necessarily be exceedingly complex. The magnitude of a monitoring plan will be large because of this complexity and the large size of the Bay system; its drainage basin occupies about 64,000 square miles, and the surface of the Bay and tributary waters occupies 4400 square miles. However, an organized approach can reduce the complexity to manageable limits and scale the large size and diversity of the system down to comprehensible dimensions.

The purpose of this document is to define a framework and strategy for the Master Monitoring Plan for the Bay, identify some important elements of the plan, and suggest how research might be integrated into a long-term operational monitoring effort. A summary is presented of the Bay's main problems identified by the characterization process (Flemer et al. 1983) and a discussion is given on how monitoring should be coordinated to address these and other problems which may occur. In addition, the document summarizes the existing monitoring programs and assesses their ability to provide the information needed to begin to solve these

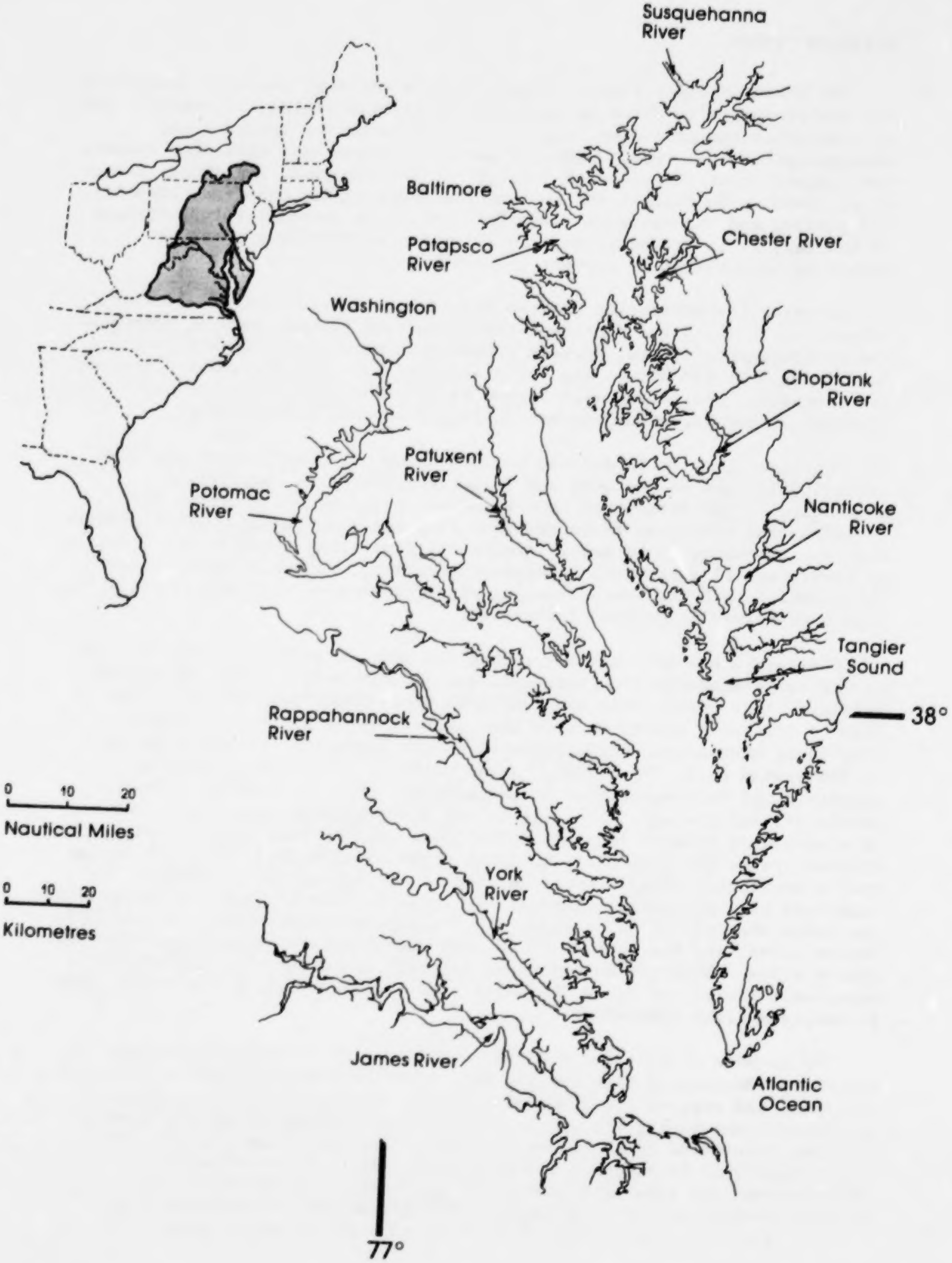


Figure 1. Chesapeake Bay.

problems. Requirements and recommendations for biological resource monitoring are outlined as well as a general data management plan for all types of monitoring. A key feature of this data management plan is the emphasis on quality assurance.

This document is divided into 3 sections. Section 1 gives the reasoning behind the need for a new monitoring strategy; section 2 presents the theory and rationale which went into the plan's formulation; and Section 3 presents the plan itself.

SECTION 1

# THE NEED FOR A NEW BAY-WIDE MONITORING STRATEGY

## STRENGTHS AND WEAKNESSES OF EXISTING PROGRAMS

The attempt to characterize the Bay (Flemer et al. 1983) using past and present monitoring data revealed some strengths and weakness concerning this data collection. The next three areas will discuss (1) the major problems with the data collection, (2) what the data revealed about the state of the Bay, and (3) recommendations for future data collection and analysis.

### Major Problems with the Data Collection

First, there were major problems with the data base as seen in the lack of consistent data collection in several large areas of the Bay, such as the Eastern Shore regions and the lower Bay. Many of these areas are biologically important areas such as finfish-spawning grounds. Second, temporal coverage could be improved, as could the power of multifactorial analyses, by collecting water quality information that is coupled with living resource information and third, there was a lack of consistency in selection of parameters measured. This can be remedied by selecting a core set of parameters that will always be measured. Attachment 1 discusses in more detail these and other problems with past data collection.

### What the Data Revealed about the State of the Bay

Most of the monitoring conducted in the Bay and its tributaries at present is done on a trend assessment level. Monitoring, which is designed to show cause-and-effect relationships, is accomplished under special programs usually through research agencies and institutions. Through the characterization of Chesapeake Bay (Flemer et al. 1983), data from the current monitoring programs and research efforts were used in statistical analyses and showed declines in several of the Bay's natural resources. In many instances it was possible to show correlations between these declines and certain water quality parameters which were sampled concurrently with the living resources data. In many areas of the Bay this was not possible because concurrent water quality data were not available. In addition, in most cases, direct cause-and-effect relationships were impossible to conclude because the monitoring programs were not designed to address this issue.

The major environmental problems that emerged from the characterization process (Flemer et al. 1983) provide a conceptual basis for a monitoring plan. Each problem may be formulated as one or more specific hypotheses that may be tested. This approach ensures that data will be used to address the most important problems and that explicit decisions will be made regarding what is to be measured and the format of the experimental design.

The characterization process (Flemer et al. 1983) and research by many institutions aided the CBP in identifying the following key problem areas:

1. An increase in the extent of oxygen deficient water in the mid-Bay region.
2. A decline in submerged aquatic vegetation (SAV).
3. A decline in freshwater spawning (anadromous) fish.
4. A decline in the oyster fishery (particularly spat set success).
5. A proliferation of nuisance algae in upstream portions of the Bay and its tributaries.
6. A threat of toxic substances to some living resources.
7. A decrease in water clarity.
8. A need for a more coordinated effort in the collection of baseline information on the Bay.
9. A need for information to formulate, calibrate, and verify hydrographic and water quality models of the Bay.
10. An urgent need to understand the causes of undesired changes.

Three of these problem areas involved declines in important living resources of Chesapeake Bay -- SAV, finfish, and oysters. The remaining areas could be directly or indirectly related to these three resources. With this in mind CBP attempted to formulate monitoring strategies that were designed to further the understanding of cause-and-effect relationships between water quality and these living resources. Questions designed to reveal the causes of the declines seen in each of these resources were formulated from what is known about the resources' life cycles and how they interact with their environment. Monitoring strategies built around this framework aid in the separation of anthropogenic from natural causes and bring the manager closer to pin-pointing the exact cause(s) of the decline. Some specific hypotheses addressing these major problems and associated rationale, answers from characterization (Flemer et al. 1983), and suggested tests for the hypotheses are shown in Attachment 2 of this monitoring report.

## Recommendations for Future Data Collection

To improve data analysis, several areas of data collection should be refined. Some of these improvements include standardization of techniques, congruent water quality and biological sampling, consideration of natural variability when designing sample intensity and frequency, and recognition of local system features. In addition, several areas of needs were identified including: 1) the need for true abundance measurement; 2) the need to understand biological community structure and interactions; and 3) the need to develop bioassay procedures that allow interpretation of laboratory derived results of field conditions. Attachment 4 discusses each of these recommendations, as well as specific biological sampling recommendations, in more detail.

## SUMMARY

The need for a new monitoring strategy issues from these facts:

- there are data collection gaps;
- there is duplication of effort;
- water quality and living resources data are collected separately;
- no Bay-wide monitoring goals and objectives have been set; and
- monitoring and research have not necessarily supported each other.

With these ideas in mind the monitoring team [Bay scientists, and state (MD and VA), and Federal representatives] formulated a proposal for a Bay-wide monitoring strategy.

Each of the state monitoring programs described in Attachment 3 are designed with a specific purpose in mind which may cover only a small portion of a river or embayment. The philosophy behind the new monitoring strategies proposed in this report is not to countermand the state's specific monitoring objectives, but to better coordinate the efforts and manage the data collection and storage to attack the problems involving the Bay's declining resources (see maps of state and Federal monitoring stations, Attachment 3).

SECTION 2

# THE THEORY BEHIND THE PLAN

## IMPORTANT GUIDELINES

A number of important guidelines are suggested for the satisfactory development of a monitoring plan. Some of these are self-evident but others are not.

- Management goals must be established for major zones or regions of the Bay and tributaries.

The over-all management goal is to maintain the natural biological productivity and enhance it where science and management indicates such would be appropriate. Regions such as Baltimore Harbor and the Elizabeth River (near Norfolk) may receive future reductions in the discharge of materials that cause problems, but it may not be realistic to expect such areas to be rehabilitated to former "pristine" conditions. These may be extreme examples of lost living resource values; however, other similar regions may be returned to a more natural productive condition without reaching the former productive potential.

- Objectives must be stated for monitoring.

The objectives will form the "road map" by which we can measure progress in assessing the health of the Bay and evaluate the success of management efforts.

- Monitoring must be carried out in the context of environmental uncertainty.

This statement is based on the observation that environmental measurements inherently have a probability distribution. Conclusions reached from such measurements must address the statistical uncertainty associated with sampling and analytical efforts to be meaningful. However, another important consideration is the uncertainty associated with our understanding of the dynamic nature of an ecosystem's structural and functional properties (Flemer and DeMoss 1982). In this context, there continues to be questions about what to measure, where, and with what frequency.

- It must be recognized that outputs of the Bay ecosystem, such as fisheries, result from the interaction of a number of ecological processes.

For example, human effects on the fisheries can be direct, as in over-fishing, but often it is intervention of various Bay processes (e.g., nutrient cycling, changes in freshwater flow, turbidity, and its effects on photosynthesis) that can ultimately damage the fisheries.

- An operational framework that links sources of problem materials with their transport, fate, and effects needs to be maintained.

This simple framework (Figure 2) will require constant and consistent monitoring of point and nonpoint sources of pollutants, often far removed from the tidal Bay system proper. It will also require a close coupling between present land use activities, a data management system, and flexibility in over-all sampling design to track environmental planning efforts which will assist future allocation of monitoring resources.

- Monitoring without an effective data management system can lead to resource-use inefficiencies and waste.

This point is self-evident in light of the vast amount of data in hand and anticipated in the future. Furthermore, an effective data management system is essential to periodic resource assessments.

- A system or Bay-wide perspective is essential.

The future water and sediment quality of the Bay and its tidal tributaries will continue to depend on inputs of material from various land-use activities in the drainage basin, air-shed, and ocean boundary. A holistic view of the Bay ecosystem is essential if we are to appreciate the inter-connecting nature of ecological processes (White and Millington 1982).

## IMPORTANT CONSIDERATIONS IN THE DESIGN OF A MONITORING PLAN

### The Importance of Baseline Monitoring

Baseline sampling as we are defining it for this document is the collection of data at defined locations over time by defined procedures. It is useful in describing the basic features of the Bay ecosystem and can help portray change. However, baseline monitoring alone cannot provide adequate information needed to understand the meaning of a change in the state or level of a variable. The Bay system is an ecosystem whose properties are dynamic and interacting (U.S. EPA 1982a). Thus, measuring changes in phytoplankton, copepods, oyster and fish stocks or water and sediment quality (i.e., nutrients and toxic materials) will not provide adequate data to understand or infer much about the nature and effects of a stress or the response time following the relaxation of a stress.

### The Need for Hypothesis Testing

Hypothesis testing, whenever possible, ensures that a focus on sampling design and evaluation of the data in terms of accepting or rejecting an hypothesis will occur. Without a question in mind it is difficult to interpret data. An extension of this concept leads to mathematical models.

### The Complexity of Bay Ecological Processes

Another important consideration is the recognition that ecological processes in the Bay operate at varying spatial and temporal scales (Harris 1980, Figure 3). For example, it is known that there are daily changes as well as seasonal and locational differences in the levels of dissolved oxygen. Thus, how the spatial and temporal scales are viewed is critical to how a monitoring plan is designed and the results interpreted. A useful way to view the ecological complexity of the Bay and link various spatial and temporal scales into an analytical framework for coupling field

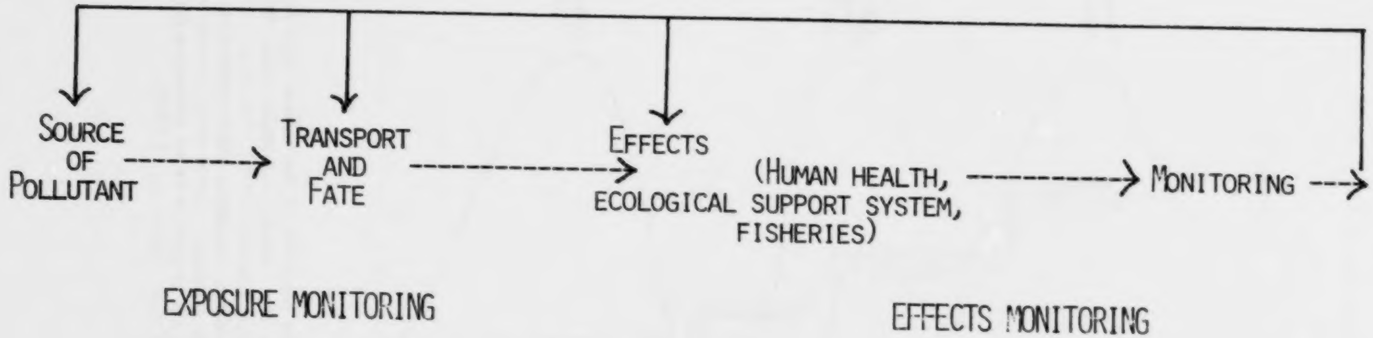


Figure 2. Monitoring flow diagram showing the relationship of monitoring to source, transport, fate and effects with separation between exposure and effects monitoring.

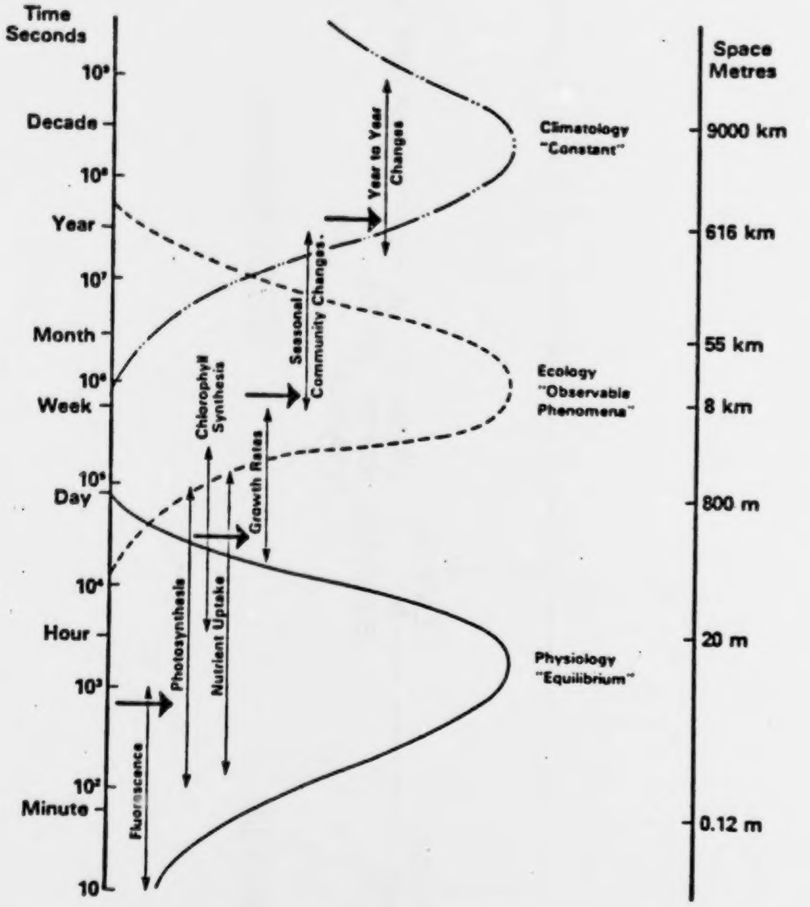


FIG. 3., A summary of the hierarchy of the various algal responses to the spectrum of environmental fluctuations. The temporal and spatial scales are linked by the processes of horizontal turbulent diffusion (Bowden 1970). The three bell curves roughly define the scales of interest to physiologists, ecologists, and climatologists. The horizontal arrows are meant to show that higher frequency (lower level) processes collapse into higher level responses. The figure does not pretend to be an exhaustive description — for more details and references see text. (from Harris, 1980).

observation and experimental work, including mathematical modeling, is exemplified by an hierarchical design of research in submerged aquatic vegetation (Kemp et al. 1980, Figure 4).

## Segmentation of the Bay

The physical complexity of the Bay can be portrayed in a simplified and organized way as proposed by the U.S. Environmental Protection Agency's Chesapeake Bay Program (Figure 5). The approach is to segment the Bay system into a group of areas that share common features. Major classes within each major tributary include tidal fresh water, the turbidity maximum zones and the two-layered estuarine region. The lower main-stem of the Bay has some unique features in terms of estuarine circulation. However, this approach provides a first-order level of comparison and helps define limits on ecological processes for the Bay and tidal tributaries that are controlled primarily by salinity and estuarine circulation.

## Coordination of Effort

A principal weakness in many monitoring efforts is the lack of coordination in sampling among the various scientific and management agencies. This problem is acute when piecemeal sampling is undertaken. Simultaneous sampling which includes key variables can provide greater insights as to the probable cause of an effect. For example, studies that examine the phytoplankton distribution in the Bay without measuring important physical and chemical variables will not allow an opportunity to analyze for meaningful correlations. An example of this problem is described in detail for the fluvial James River at Cartersville whereby inconsistencies in the dissolved oxygen data arose because appropriate variables and frequencies of sampling were not included in the baseline monitoring (Comptroller General 1981).

## Changes in Methodology

Monitoring studies that extend over many years are subject to methodological change. This change may be appropriate but, it is essential to attempt to calibrate the old and new methods for their comparability. The importance of this consideration was recently shown in Lake Michigan where approximately 90 years of water quality data at selected drinking water plants were seriously questioned (Shapiro 1983).

## Quality Assurance

It is critical that a rigorous quality assurance plan be adopted for the Bay-wide monitoring plan. Criteria should be established before data are compared. Otherwise, methodololgical differences, lack of analytical control, and other factors will limit the utility of such data in trend analyses.

## A Specimen Bank

Another important consideration is the role of developing a specimen bank where environmental materials (e.g., sediments and living resources) will be stored, under appropriate and rigorously controlled conditions, for future reference. This concept is straightforward--"it is important in

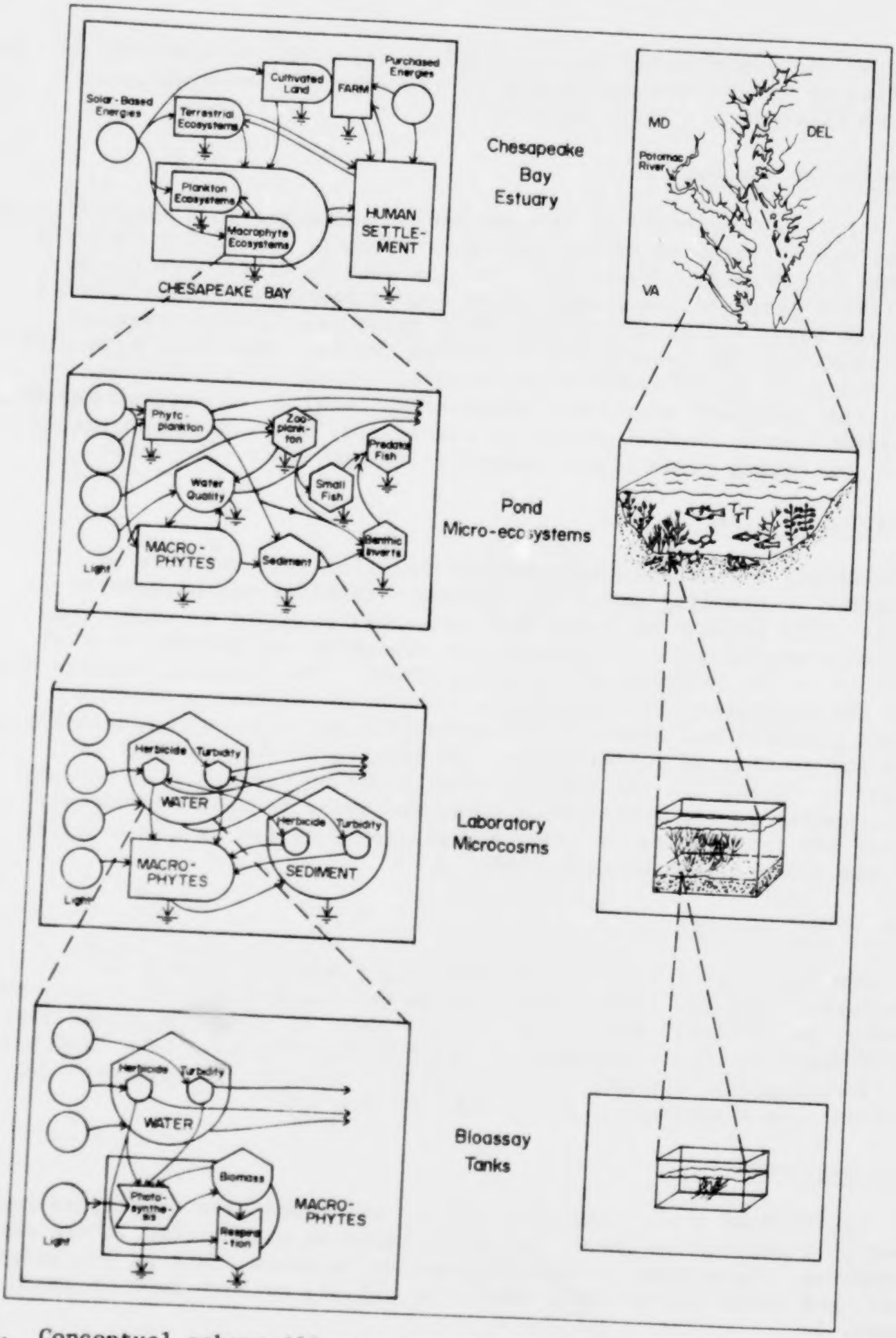
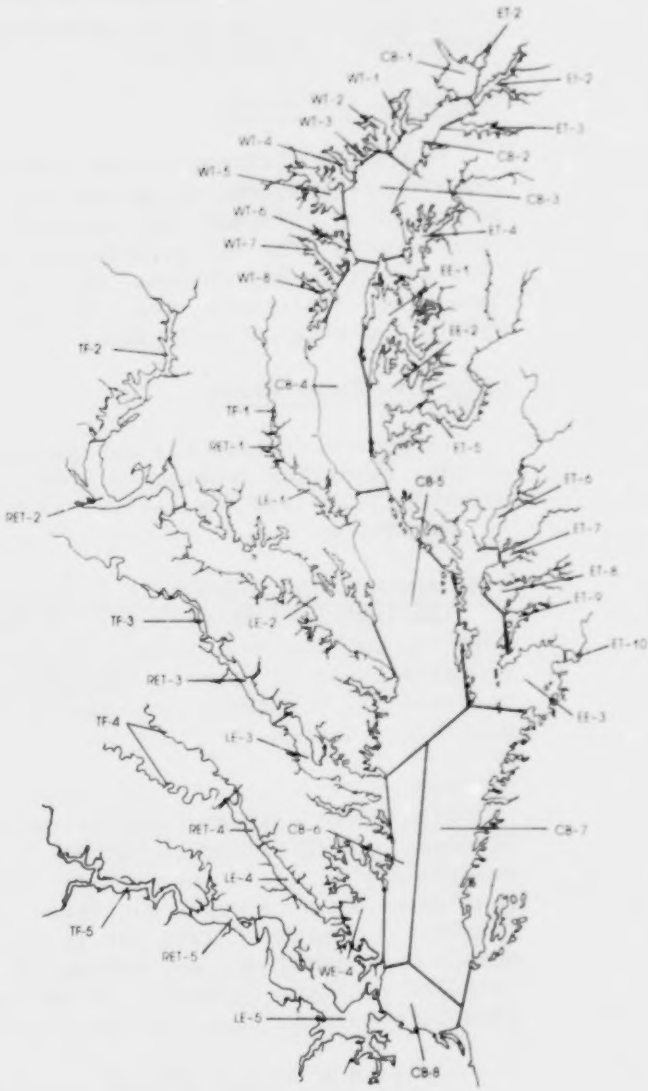


Figure 4. Conceptual scheme illustrating the hierarchical design of research on submerged aquatic vegetation and associated Chesapeake Bay ecosystems. The illustrations on the right show various scales of research focus, and model diagrams on the left represent principal parts and processes of systems which correspond with the hierarchical level being studied. Graphic symbols are those of H.T. Odum 1971. ( from Kemp et al. 1980)

| Segment | Characteristics |
|---|---|
| **Tidal-fresh reaches** | |
| Ches. Bay N. (CB-1)<br>Up. Patuxent (TF-1)<br>Up. Potomac (TF-2)<br>Up. Rapp. (TF-3)<br>Up. York (TF-4)<br>Up. James (TF-5) | • dominated by freshwater inflow of the river system<br>• spawning areas for anadromous and semi-anadromous fish<br>• resident habitat for freshwater fish<br>• dominated by freshwater plankton and aquatic vegetation |
| **Transition zones** | |
| Up. Bay (CB-2)<br>M. Patuxent (RET-1)<br>M. Potomac (RET-2)<br>M. Rapp. (RET-3)<br>M. York (RET-4)<br>M. James (RET-5) | • slight salinity (3–9 ppt, mean) influence<br>• zones of maximum turbidity where suspended sediment causes light limitation of phytoplankton production most of the year<br>• areas are valuable sediment traps, concentrating material associated with sediments including absorbed toxic chemicals |
| **Lower estuarine reaches** | |
| Up. C. Bay (CB-3)<br>L. Patuxent (LE-1)<br>L. Potomac (LE-2)<br>L. Rapp. (LE-3)<br>L. York (LE-4) | • upstream limit of deep water anoxia<br>• moderate salinity (7–13 ppt, mean)<br>• two-layer, estuarine circulation driven primarily by freshwater inflow |
| L. James (LE-5)<br>Sec. W. Tribu (WT-1-8)<br>E. S. Tribu (ET-1-10) | • weaker estuarine circulation characterized by limited flow/flushing characteristics<br>• water quality controlled by the density structure of the main stem of the Bay at the tributary mouth |
| **Lower Main Bay** | |
| Chesapeake Bay Lower Central (CB-4) | • water deeper than 30′ usually experiences oxygen depletion in summer—can be toxic to fish, crabs, shellfish and benthic animals.<br>• mean salinity of 9 to 14 ppt<br>• rich in nutrients |
| Chesapeake Bay South (CB-5) | • influenced by inflow from Potomac and Patuxent and rich in nutrients<br>• mean salinity of 10 to 17 ppt<br>• subject to summer anoxia and contains most of the deeper Bay waters |
| Chesapeake Bay General West (CB-6) | • net southward flow<br>• mean salinity of 14 to 21 ppt |
| Chesapeake Bay General East (CB-7) | • net northward flow<br>• mean salinity of 19 to 24 ppt |
| Chesapeake Bay Mouth (CB-8) | • net southeastward flow<br>• mean salinity of 19 to 23 ppt |



### Embayments

| | |
|---|---|
| E. Bay (EE-1)<br>L. Choptank (EE-2)<br>Tangier Sound (EE-3)<br>Mobjack Bay (WE-4) | • have salinities similar to adjacent Bay waters<br>• shallow enough to permit light penetration for submerged aquatic vegetation growth<br>• influenced strongly by wind patterns |

Estuaries have a capacity to assimilate waste before experiencing significant ecological damage; but, this ability can vary dramatically from one area to another. To assess water quality of areas with similar characteristics the CBP divided the Bay into regions, or segments using natural processes such as circulation and salinity. These 45 segments were used as a framework to map and evaluate past and present conditions of Chesapeake Bay.

Figure 5. Segments of Chesapeake Bay and their principal characteristics.

analyzing trends in exposure to previously unrecognized toxic materials or toxic materials for which analytical techniques may at present be inadequate" (Luepke 1979).

### Informing the Public

Concerned citizens in the Chesapeake Bay are an asset to managers and researchers involved in protecting Chesapeake Bay. It is important for the public to be informed that monitoring data are actually used in resource assessments. The better informed citizen has a clearer view of how to participate in Bay issues. One way of keeping open communication between managers, researchers, and citizens is through a citizens' volunteer monitoring program (Attachment 5).

### Long-Term Commitments

Long-term commitments are an essential ingredient because interpretation of data resulting from these programs often involves dealing with long-term natural cycles and the ability to reliably detect subtle human intervention in the system.

### A Management and Regulatory Framework

Informational development, to address management and regulatory concerns for the Bay system, requires that observed efforts be linked to a probable cause or causes. Therefore, knowledge about sources of problems or potential problems, can provide guidance to the development of a monitoring design.

#### Sources--

Within the segmentation scheme, the tidal waters of Chesapeake Bay can be viewed as an interface between the land and the atmosphere. Hazardous materials that enter the estuary mainly via fluvial sources, should be considered in a monitoring scheme. Classes of materials can be conveniently grouped into nutrients, toxic chemicals (including trace metals and organics), and sediments. They can be catagorized as point and nonpoint sources, depending on whether they emanate from a confined structure such as pipes or from diffuse sources such as agricultural runoff.

Emphasis should be placed on developing a fall-line or head-of-tide sampling regime that flags a material that would present an additional load to the Bay, and which would have unacceptable consequences. The idea of unacceptable consequences is related to management criteria which are usually framed in terms of uses of the estuary and its resources. It should be noted that sources for a particular segment include other boundaries (e.g., the ocean or a more seaward segment), the Bay bottom, and the atmosphere.

The activity of assessing source material should include a series of bioassays to help evaluate the relative toxicity of anthropogenic substances. These bioassays should be tested on a variety of organisms and biological communities, including micro- and mesocosms. The latter is necessary because single-species bioassays often are poor predictors of the field behavior and the effects of industrial chemicals. Emphasis should be placed on sub-acute effects and possible shifts in the food web. The greater ecological insights gained on source material effects will lead to a more rational basis for the prevention of pollution.

Transport and Fate--

As indicated above, the transport and fate aspect is coupled to the source identity. The significance of toxic chemicals and associated fine sediments argues strongly for the development of physical transport models. Because of logistical and cost problems, the Chesapeake Bay-wide monitoring of materials from a transport and fate consideration will be difficult to achieve on a spatially and temporally dense sampling plan. Taking data to calibrate and verify transport models or update them seems to be a better strategy than attempting to directly assess the transport and fate components on a sampling-intense schedule. Site-specific problems may fall outside of this argument, but tributary or Bay-wide efforts should use the predictive capacity inherent in mathematical modeling with a balanced use of ground truth.

Important questions will continue to require refinement; for example, to what extent do materials get locked up in river and reservoir sediments and organic matter which preclude materials from reaching tidal waters; and under what hydrographic conditions do selected materials pass through tributaries to the main-stem of the Bay and vice versa?

Effects--

This topic is poorly developed in an ecological context except for nutrients where the capability is largely in terms of predicting changes in the concentrations of dissolved oxygen (i.e., little is known about food-web effects of nutrients). Research on the basic effects of nutrients, at the level of food-web relationships, is needed before a rational effects model can form the core of a nutrient monitoring plan. In this context, toxic chemicals can be modeled mostly in a qualitative way using conceptual effects models. Basic work is needed, especially in the area of obtaining chemical tags or markers, to trace the flow of materials in the food webs and in the ability to sort out meaningful signals in a typically "noisy" environment.

As a basic strategy, the present effects models being developed by the scientific community should be used to predict the effects, and specific research studies should use the long-term monitoring data to validate the predictions. This approach has immediate utility for nutrients; but since toxic chemical effects are much less clearly defined, the approach will be more qualitative. The Application of conceptual mathematical models may help resolve critical management decisions in the future. For example, a significant increase in nitrate loading to the upper Chesapeake Bay may have minor effects on the main-stem; however, it has been speculated that this source may be transported down-Bay to the Patuxent where an already stressed system may be further degraded. In this framework, mathematical models should be recognized as essential tools in any monitoring plan.

An extension of the approaches described in Section 3 can be integrated into the source/transport/fate and effects framework. Attachment F is an example of a study design that is parallel to the regulatory framework described above.

Point Source Monitoring--

The Chesapeake Bay Program is recommending that biological and chemical analysis of effluents from industrial and municipal dischargers be collected and stored in a permanent data base. The CBP's computerized procedure for rapid, in-stream identification of wastewater effluents should be used to evaluate the quantity and nature of toxicants being discharged from point sources and accumulating in the bottom sediments. This "fingerprinting" methodology is described in Appendix D; an example of a "chromatograph" or "fingerprint" is shown in Figure 3 (Appendix D). In those areas where biological communities become endangered or stressed, fingerprints of sediments can be compared to fingerprints of point source effluents to locate and reduce that particular toxicant.

In addition, a biomonitoring protocol is recommended to be adopted by the states as part of the NPDES permitting program to ensure that wastewater discharges are not hazardous to biota. This biomonitoring program can be modeled after the Monsanto protocol developed by the CBP (Wilson et al. 1982)(Appendix D). The methods, organisms, and data analysis can be adapted by the states to address their mutual needs and concerns. However it should be uniformly done by the states in conjunction with EPA approved methods (U.S. EPA 1982). The options and recommendations for biological and chemical tests (shown in Table 16, Appendix D of Wilson et al. 1982) should be considered.

Nonpoint Source Monitoring--

Research, monitoring programs, and control strategies to reduce urban runoff should be continued and strengthened by the localities which are most directly affected. For example, the Baltimore Regional Planning Council recommends vigorous implementation of 208 plans which identify urban management strategies to protect water quality in those areas where urban runoff controls provide the most effective results.

## AN ANALYTICAL FRAMEWORK

Monitoring programs are designed to meet one or more of the following objectives:

- detection of environmental change
- assessment of regulatory compliance
- provision of a framework for design and conduct of research on causes and effects
- predictive assessment
- determination of management action effectiveness; and
- provision of a reference pattern.

These elements represent an ordered series for understanding the Bay. Each element has different information requirements, sampling design, and analytical approaches. They all are important and necessary for a comprehensive master monitoring plan for the Bay. These elements or objectives can be re-cast into three primary analytical levels, each having managerial flexibility by permitting varying levels of activity. This hierarchical structure basically reflects one of confidence and power in the nature of the information. An increased cost may be associated with higher levels but this is not necessarily true because even extensive baseline or zero-order predictive efforts can be expensive. Each objective is described below, followed by a re-structuring into the three primary analytical levels.

Environmental Change Detection

Assuming that meaningful baseline variables have been selected, the data can be used to determine whether or not a change has occurred in that variable over a period of time. This objective can form the primary means for providing a screen or "flag" for potential environmental problems.

Compliance Monitoring

This is conceptually a simple problem. It requires the detection of change from "ambient" conditions which are established through a defined set of regulatory standards. In practice this objective may not be simple to execute because the physical dimensions of the problem range from site-specific to regional.

Determination of Causality and Prediction in an Ecosystem Context

As is well known, cause and effect determination is usually difficult to make, especially in complex systems such as Chesapeake Bay. The establishment of the causes of specific changes is a key element in the resource decision-making process. Though resource managers are frequently unable to wait for a strong case of causality to be made, they feel a sense of increased confidence in decision-making when a decision is supported by a reasonable causal explanation. However, causal explanations require careful attention to detail, often involving statistical hypothesis testing, field and laboratory experiments, and conceptual and mathematical modeling with varying levels of complexity. This process will lead to improving predictive capabilities.

Determination of Management Action Effectiveness and Predictive Accuracy

Monitoring to determine whether management actions have been effective and predictions accurate is important in that it either reinforces predictions and management actions or it forces a reevaluation of them, and the search for alternative solutions. If it is found that our predictions and management actions are not effective, we may be forced back into the hypothesis testing mode.

## ELEMENTS OF THE MASTER MONITORING PLAN

To achieve managerial flexibility, the following plan is structured in an hierarchical manner, each expressed as a goal. Level III is intended to provide a greater confidence than the preceeding levels with regard to explaining the meaning of the data.

Level I: Descriptive--to allow the monitor to describe statistically changes in the parameters measured over time and make trend assessments.

Level II: Analytical--to allow the monitor to test for meaningful correlations among several of the parameters measured over time with defined statistical significance.

Level III: Interpretive--to allow the monitor, analysts, and scientists to determine cause and effect relationships among several of the parameters measured over time and to understand and predict interactions among ecosystem components and the probable effects of changes with statistical characterization.

Baseline data development (levels I and II) will be largely descriptive; thus, it sets the limits within which initial hypotheses are formed. Baseline monitoring has and can continue to help describe the spatial and temporal variability associated with the measurement of environmental parameters. It also serves as part of a long-term environmental screening technique that detects change in situations where an hypothesis has not yet been formulated .

When it is discovered through baseline monitoring that a problem exists, the next step in the plan is to develop an analysis of all relevant data. Then one can formulate an hypothesis followed by a statement of rationale and test of the hypothesis. This approach is based on the conviction that an hypothesis framework is the most explicit form of coupling between scientific knowledge and our ability to detect important changes in the Bay. As an analytical framework, it directs our thinking to deal with uncertainty. The suggested approach can be viewed as a "road map" that assists in organizing information so that answers to questions will be matched.

Finally, an hypothesis framework does something else that is critical. It forces those responsible for implementation of the plan to periodically make assessments as to the weight of the evidence for accepting or continuing to reject the hypothesis. The most useful hypotheses will be coupled in a way that provides insights into the conceptual model that addresses the source of a problem material, its transport and fate, and its ultimate effects. This approach will help define the relative influence of human intervention on processes that have a characteristic natural variability.

The following plan presents activities for the baseline and trend assessment goal (level I). Coverage includes the monitoring of sources of materials both at their origin, in transport media (e.g., fall line and atmospheric precipitation), and in the tidal Bay system. Effects are included for several levels of chemical and biological organization. This level of activity will be followed by levels II and III, respectively.

## **LEVEL I GOAL:** Describe Baseline and Measure Trends

Objective: To characterize the spatial and temporal pattern of living resources and environmental variables so that a meaningful baseline is developed and applied over time for the Bay system.

Rationale: Baseline monitoring is largely a zero-order activity (i.e., little or no immediate predictive value). This is so because baseline monitoring focuses on point-in-time measurements of ambient conditions. It typically does not address questions of ecological function or processes. Because complex ecosystems such as Chesapeake Bay probably have multiple steady states in terms of biological out-puts (May 1977), it is not surprising that baseline monitoring has limited capabilities. However, such recognition is not intended to denigrate baseline monitoring but place it in perspective and ensure that practitioners of such activities have realistic expectations.

**LEVEL II GOAL:** Develop Analytically Significant Sets of Correlations With Defined Statistical Significance

Objective: To develop a series of relationships that can be tested as hypotheses that focus on important questions regarding the Bay's living resources and environmental variables.

Rationale: Many interesting and ecologically plausible relationships are known to exist between environmental variables and living resources. Discovery of these relationships often results from experience and knowledge about how variables are related through common patterns. A grouping of common patterns can be formulated into a conceptual framework or model. The conceptual model is a tool that is used to track the behavior of various interactions expressed either as a bivariate or multi-variate set of interactions.

In an attempt to increase the generality of the observed relationships (that is, does one factor change predictably in relation to one or more factors) it is desirable to test the nature of the relationship under a range of circumstances. If generality can be combined with realism and predictability, then a good understanding of how some aspect of the Bay ecosystem functions has been developed. This is the basis of understanding cause-and-effect relationships and leads naturally to level III.

In an ecosystem in general, and especially one as complex as Chesapeake Bay, one might expect to find many relationships among variables that vary in their intensity. Many relationships often are poorly correlated but may reflect meaningful interactions. Statistical hypothesis testing is an important technique that brings a high level of objectivity in deciding whether a particular relationship occurs simply as a matter of chance. However, statistics are a tool, not a substitute for clear reasoning and accurate framing of ecological relationships.

**LEVEL III GOAL:** Develop and Interpret Predictive Models based on Cause-and-Effect Relationships

Objective: To analytically allocate cause-and-effect among the various parameters and interactions (many of which were previously described as level II examples) that constitute the critical elements of the Chesapeake Bay ecosystem and to develop predictive models that incorporate cause-and-effect of multiple parameter interactions.

Rationale: Because Chesapeake Bay is an ecosystem which has biological, chemical, physical, and geological components, it must be understood and managed as a system and not necessarily as the sum of its components (U.S. EPA 1982a).

This section builds upon the current scientific knowledge concerning cause-and-effect relationships from an ecological perspective. Emphasis will be placed on models that are composed of coupled processes. At this stage in the Bay's management and scientific support, it is possible to consider an exceedingly large number of options on what would be modeled and approaches that might be fruitful. The need for predictive models that are cost-effective is great. Many processes are still poorly understood and are more appropriately viewed within a research development context (e.g., a suspended sediment transport model which has important implications for assessment of toxic chemical exposure to organisms, food webs, and people). An example is work done on modeling the transport of Kepone in the James River estuary (Nichols and Cutshall 1979).

In light of what has been shown to be directly useful, there are several large-scale models that warrant further application. Others require improvement. An example of a useful model that has direct application is the nonpoint source model adapted to the Chesapeake Bay drainage basin for the Chesapeake Bay Program. A model that requires further development is the CBP model that predicts levels of dissolved oxygen based on coupling transport and mixing processes, photosynthetic-nutrient processes and decomposition processes. Under varying stages of research and development are fisheries models which include statistical and deterministic functions.

There are a number of models that focus on ecosystem processes that have relevance to management questions but do not predict specific outputs in terms of a particular fishery. Many of these models have been developed for areas other than Chesapeake Bay but may be transferred to the Bay after additional research, calibration, and verification steps are undertaken. Examples of such efforts include a phytoplankton model of Saginaw Bay, Lake Huron (Bierman et al. 1980), a simulation model for coastal zoobenthic ecosystems (Albanese 1979), a coastal marine ecosystem model of Narragansett Bay (Kremer and Nixon 1978), a carbon flow model of a Georgia salt-marsh ecosystem (Dame 1979) and the general ecosystem model of the Bristol Channel and Severn Estuary, England (GEMBASE)(Radford and Joint 1980). The purpose here is not to give a review, which is probably impossible in limited space, but to suggest that progress is being made (Platt et al. 1981) and future management concerns for the Chesapeake Bay system can benefit from formal modeling efforts. A key point that sometimes is overlooked is that models, whatever their complexity and stated objectives, are nothing but tools and can have direct management application for the Bay.

## MONITORING, RESEARCH, AND MANAGEMENT

It is true that in the strict definitions of the words "monitoring" and "research" they are two distinctly different subjects. However, in order to ensure that responsible management decisions are made, these two subjects must not be separated. To solve the problems identified in the Bay, managers and researchers need to work together toward a common goal.

Figure 6 illustrates how monitoring, research, and management are intertwined. First, a coordinated effort is made to collect baseline data (levels I and II) which gives us the capability to detect changes in the parameters sampled. Through statistical analysis it is determined that a problem exists. It is then that the question-asking process and the formulation of hypotheses begins. At this point it is clear that a cooperative effort between monitoring and research needs to take place. This is a level III effort and it involves not only parameter sampling but also an experimental design, field and lab research, and statistical analysis. This level III effort is commonly known as a special study. At times these special studies are handled by the state government through an in-house effort. At other times they may be contracted out to one of the research institutions in the area. In many cases, research institutions will incorporate the problem into their efforts.

Theoretically when the special study (level III) is completed, a better understanding of the causal relationships should exist. This information is passed on to the manager who will then take some kind of action to alleviate the problem. The monitoring effort will then drop back to level I or II, which has been ongoing. However, now two additional objectives come in to play. If the manager proposes some new regulations, a monitoring effort will have to be carried out to make sure that those regulations are being observed. In addition, the special study area will need to be monitored to determine whether or not the management action has produced the desired effect and predictions were accurate. If not, the process will go back to the level III position.

What is being proposed in this document is not a new concept since monitoring and research have been going on for years or decades for some problems. The key issue here is to better coordinate these activities and to make sure that monitoring is done with specific objectives in mind.

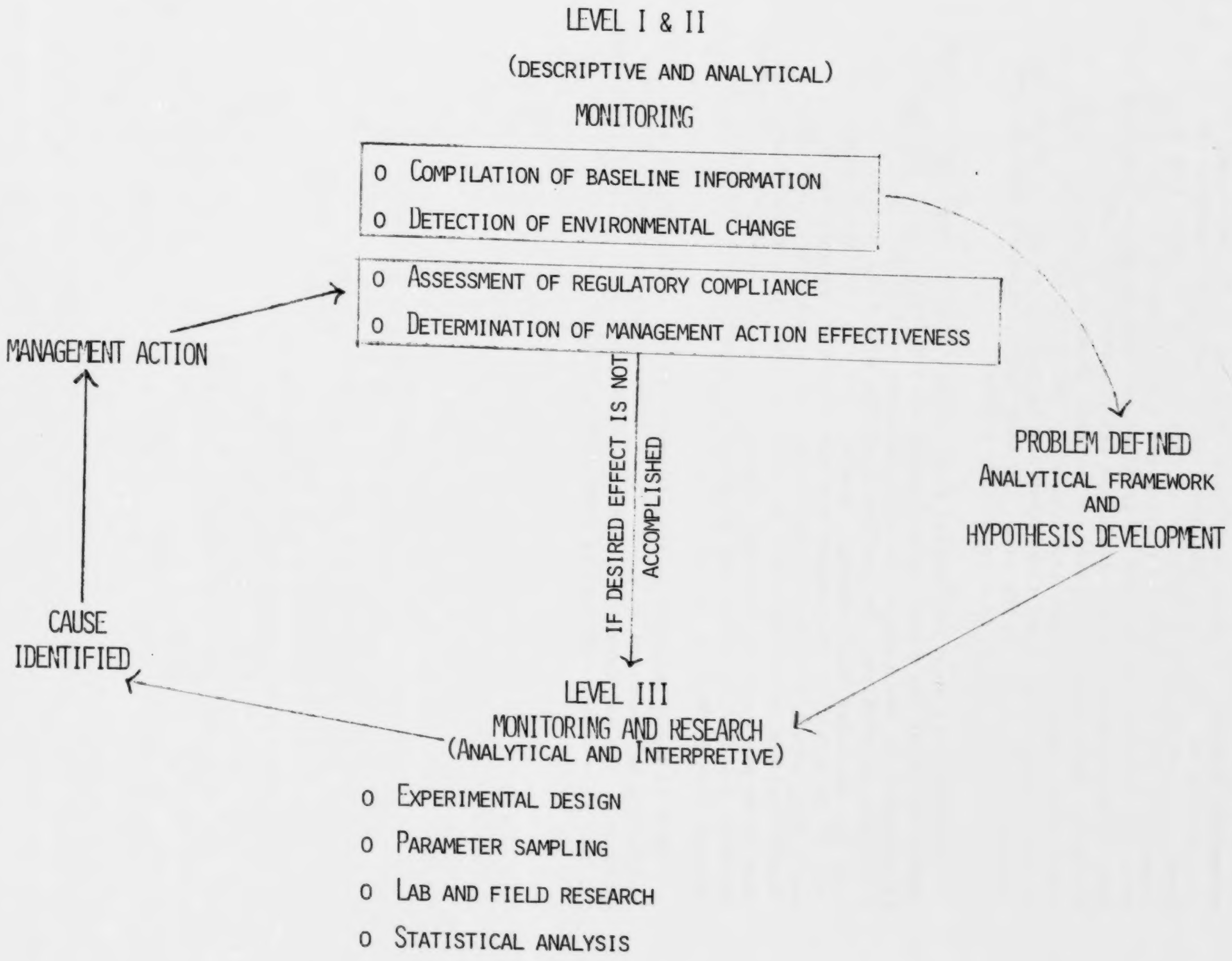

LEVEL I & II
(DESCRIPTIVE AND ANALYTICAL)
MONITORING
o COMPILATION OF BASELINE INFORMATION
o DETECTION OF ENVIRONMENTAL CHANGE
o ASSESSMENT OF REGULATORY COMPLIANCE
o DETERMINATION OF MANAGEMENT ACTION EFFECTIVENESS
PROBLEM DEFINED
ANALYTICAL FRAMEWORK
AND
HYPOTHESIS DEVELOPMENT
IF DESIRED EFFECT IS NOT ACCOMPLISHED
LEVEL III
MONITORING AND RESEARCH
(ANALYTICAL AND INTERPRETIVE)
o EXPERIMENTAL DESIGN
o PARAMETER SAMPLING
o LAB AND FIELD RESEARCH
o STATISTICAL ANALYSIS
CAUSE IDENTIFIED
MANAGEMENT ACTION

FIGURE 6. MONITORING, RESEARCH, AND MANAGEMENT.

## SECTION 3

# THE PLAN

The Bay-wide monitoring strategy presented here has two major components: baseline monitoring which represents level I and level II efforts for some water quality parameters and a level II effort for the living resources monitoring; and the special studies that have been defined by the baseline monitoring.

## BASELINE MONITORING

Baseline monitoring is the backbone for building a mechanism which will lead toward understanding the Bay ecosystem. Its importance in this light should not be underestimated. The baseline plan consists of monitoring water quality (Attachment 6, Figure 6.1), sediment quality, and living resources.

In formulating this proposal several points were kept in mind:

1. Baseline data should give good time-series information concerning the problem areas defined by the characterization process.
2. Stations that have been sampled consistently for many years should be kept, where possible, to maintain the historical data base.
3. Coordination between state agencies, and state and Federal agencies in their sampling programs will make sampling more efficient and may reduce total costs.
4. Stations should be placed not only in areas where known problems exist but also in areas that in the past have been considered "pristine".
5. Water quality stations and living resource stations should be coordinated, where possible.
6. Some consideration should be given to circulation processes in the Bay and how they will effect data collection.
7. Geographical coverage should be balanced against comprehensive temporal coverage.
8. Stations should be placed in areas which have particular or special biological importance such as in the major striped bass spawning grounds.
9. Funding constraints need to be considered.
10. Monitoring programs should have built-in flexibility.

## Water Quality Monitoring

This document presents one ambitious proposal for water quality baseline monitoring (Attachment 6, Figure 6.1; Table 6.1). This was formulated after close assessment of the present state and Federal monitoring programs (Attachment 3). Where there were overlaps, stations were combined. Where there were gaps, stations were added. In many areas this process meant an actual reduction in the number of stations over what is presently being done. It is highly possible that the water quality plan has more or less stations than will be needed. A further reduction or addition of stations can only be accomplished after this plan has been statistically analyzed following several years of data collection. Most of the fall line stations (Attachment 6, triangles on Figure 6.1) are presently occupied by the U.S. Geological Survey and it is recommended that these staions be continued (see Attachment 3 section B for a description of USGS stations), and that similar observations be added for the Chester, Nanticoke, and other tributaries on a calibration basis. In addition, the two NOAA current and circulation stations located off the Patuxent River and at the mouth of the Chesapeake Bay should be maintained. These stations are continuous monitors that give constant readings of current speed and direction, depth, conductivity, temperature, and pressure. These baseline stations (Figure 6.1) are, for the most part, concerned with water quality parameters; however, many of them were selected to be at the same site where living resources are sampled (such as oyster spat and juvenile finfish).

## Living Resources Monitoring

Many water chemical variables characterize the requirements for growth and survival of aquatic organisms. In recent years, the role of physical variables has been emphasized as limiting biotic populations, or, at least, setting a boundary in an ecosystem within which biotic elements interact. Traditionally, temperature and salinity have been known to exert important effects at the physiological level. More recently, the role of climate and its interaction with the circulation of marine and estuarine water is now acknowledged to play an important role in the distribution and abundance of many populations both directly and through processes such as "upwelling" and mixing of waters of different characteristics.

These considerations suggest that our ability to understand the raltionship between environmental variables, including water quality, and the biological components of a water body will necessarily involve processes and rates in a dynamic sense as compared to point-in-time (ambient) measurements. This is a fundamental premise which forms the underpinning of all monitoring schemes.

Specific recommendations for oyster spat set, juvenile finfish, submerged aquatic vegetation (SAV), and phytoplankton are outlined in Attachment 4. A description of SAV monitoring in the upper Chesapeake Bay and recommendations for future monitoring is included in Attachment 8. The most important change that should be considered for living resources monitoring is that sampling should be stepped up to a level II phase. That is, concurrent water quality sampling should be done as outlined in the baseline approach (Attachment 6).

## SPECIAL STUDIES

A strong program of baseline monitoring should keep Bay managers and scientists aware of how the Bay is doing and whether or not any changes are taking place in its water quality or living resources. When a problem has been identified and the cause is uncertain, a special study (hypothesis framing and testing) may have to be conducted. This level III monitoring will probably be site-specific and will require an experimental design and statistical analysis. These special studies are actually research projects that are superimposed on the central (baseline) monitoring program.

Examples of special studies that are presently being conducted are: (1) the intensive monitoring of the Potomac River tributaries around the District of Columbia (Figure 3e.13), (2) the Power Plant Siting Studies (Figures 3e.14 to 3e.16), and (3) the James River Kepone Study (Figures 3e.5 and 3e.10). These studies and others like them are vital to the continued efforts to understand the changes taking place in the Bay and its tributaries.

### An Approach to a Major Bay Problem

The EPA's Chesapeake Bay Program has developed evidence that a pool of lethal low oxygen water covering twenty percent of the Bay bottom between the Patapsco River and Tangier Island is some fifteen times larger today than in the early 1950's. It is believed that the Bay's characteristic of recycling nutrients and anthropogenically increasing nutrient loading principally from nonpoint sources are major factors contributing to the low oxygen problem. Evidence suggests that the low oxygen condition is impacting bottom-dwelling animals (oysters, crabs, soft clams, etc.) and bottom-feeding fishes (flounder, croacker, spot, striped bass, etc.).

Strategies designed to monitor the relationship of ambient nutrient to ambient oxygen, and the impact of low oxygen on biota must take into consideration 1) nutrient loading from point and nonpoint sources, 2) how these nutrients are routed through the Bay system, 3) the nutrient balance of the Bay, 4) the relationship of nutrient enrichment to low oxygen, 5) diurnal, seasonal, and annual behavior of nutrients and oxygen on a vertical and horizontal scale in the Bay, and 6) the relationship of low oxygen to the occurrence of ecologically and economically important Bay biota. A suggestion for a detailed monitoring and research strategy to follow the nutrients to oxygen to oyster relationship is described in Attachment 7.

## DATA MANAGEMENT PLAN

Data management is the process by which field measurements are recorded, transcribed, entered into the computer, quality checked, organized into a unified data base, and maintained in a secure, accurate, and efficient manner for subsequent retrieval and analysis. Data management encompasses the process that begins with the entry of field data onto data forms and ends with the archival of final data bases on some type of computer readable medium. Because the monitoring program described above will be a long-term effort carried out over several years, data management is critical and will be a continuing process, with new information added to the data base on a regular basis.

Effective data management should be an essential part of the monitoring program. It will permit access to the data by a broad community of users, including research organizations, Federal and state agencies, and citizen groups. Because data collected by many agencies using differing sampling methodologies will be integrated into an internally consistent, quality assured and documented data base, agencies other than those collecting the data will be able to utilize them in a cost-effective manner. Ultimately, as the various data collection agencies gain confidence in the scientific validity of the monitoring program and their ability to utilize other agencies data, redundant field efforts will be eliminated. Additional advantages of a Bay-wide data management program are discussed by Lynch (1983).

The data management plan for monitoring should include detailed procedures for quality assurance, which should be applied consistently to all field studies. These procedures include the design of legible field sheets, re-checking of all hand-written data, accurate data verification procedures, error checking of all data sets for internal consistency, accurate data editing procedures, and complete data-set documentation. No data set should be entered into the final data base until it has been subjected to these procedures. To ensure that the quality of data from all studies is adequate, a quality assurance manual should be developed and used by all data collection agencies participating in the monitoring program.

To ensure data integrity and security, the data management plan should include adequate procedures for data storage, computer file backup, and for controlling data base access. This will require computer hardware, software, and standard operating procedures designed specifically for the organizations that will be utilizing the data base. Because the monitoring program will include users with widely varying data processing and data management backgrounds, a professional data management staff should be established to develop and implement these procedures.

In addition to the establishment of a data management staff, the continued usefulness of the data base depends upon the commitment of the various research institutions and government agencies to participate in the monitoring program and data management plan. This commitment includes the prompt submission of field data, and carrying out of the already mentioned quality assurance procedures.

Note: At the present time, EPA is in the beginning stages of implementing a data management plan as outlined above.

## RECOMMENDATIONS

This document presents the rationale behind the development of a Bay-wide monitoring strategy and presents some specific monitoring activities. However, this is only the beginning phase in this process. Before any plan can be instituted, there are several items which need to be considered. First, the managers who direct the present monitoring programs need to be brought together to discuss how the new strategy affects what they are presently doing and how to implement the new strategy. At this time, the cost and effectiveness of the plan should be discussed. The possibility of cost sharing between the state and Federal governments in monitoring the main stem of the Bay should be given consideration.

A series of workshops should be planned where scientists and managers can be informed about and discuss items such as new advances in monitoring technology and the feasibility of standardizing methods where possible. Further consideration should be given to establishing a minimum core network of stations that focus on time-series analysis and automated sampling of key variables. Another series of workshops concerning the Bay-wide data management plan is essential.

It is further recommended that monitoring be considered when the Bay-wide institutional mechanisms are established so that some type of mechanism is devoted to the implementation of the Bay-wide monitoring strategy. A technical advisory committee should oversee the implementation of the strategy and help ensure that the collected data gets into the Bay-wide data management system. In addition, there should be a quality assurance officer to oversee the implementation of the CBP quality assurance plan and to assure that only data of suitable quality be included in the data base.

The monitoring proposals presented in this document are meant to be "straw men"; that is, they can be improved upon as additional effort is put into the implementation of a Bay-wide strategy. These strategies were formulated through a joint effort between representatives from the States of Maryland, Virginia, and Pennsylvania, and from EPA. In addition, they were reviewed by scientists and managers from the Bay area. It is recommended that this process be continued for the further refinement of the proposals.

## SECTION 4

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# ATTACHMENT 1

## MAJOR PROBLEMS WITH PAST (AND PRESENT) MONITORING EFFORTS AND DATA COLLECTION

### SPATIAL COVERAGE

There was a lack of consistent data collection in large areas of the Bay including:

1. the lower Bay, especially CB-6,7,8;
2. eastern embayments (e.g., Tangier Sound, Pocomoke, Eastern Bay, Lower Choptank);
3. smaller tributaries, especially those on eastern shore; and
4. a lack of information for the main Bay that was not taken in the main channel along the CBI longitudinal transect. There is a need for lateral transects; this is more critical in months when low DO is expected.

A lack of information exists from areas which are biologically important--or changing. Examples include:

1. The juvenile index taken in the upper Bay, Potomac, Choptank, and Nanticoke. However, water quality information from CB-1, as well as Choptank and (especially) the Nanticoke are very scattered.
2. MD SAV sampling from many smaller tributaries also in shallow water ($<$ 2 m) is scarce. Virtually no water quality data exists from some areas showing major changes (e.g., Little Choptank, Manokin, Honga, Annamessex, etc.).
3. Spat set--similar problem as described above.

There is a lack of surface to bottom values for many parameters expected to change with depth (especially in stratified portions of estuary), including salinity, temperature, DO, flow rates, and certain nutrients.

### TEMPORAL COVERAGE

Seasonal coverage is highly biased for spring and summer (this may reflect more the "productivity studies" part of the data base, as current state monitoring is year-round).

There is a lack of diurnal data for parameters which could be expected to change over a 24-hour cycle--most importantly, dissolved oxygen.

There is a lack of water quality data from the same time that important biological variables are being sampled--this is the "resource - water quality variable coupling" need.

Most importantly a lack of consistent coverage has hampered time-series analyses. Some stations are (or were) sampled sporadically. Missing years, seasons or months in the data base for various parameters and areas has been a particular problem. This gets back to the question of improving temporal coverage possibly by reducing the number of stations.

There is a need for intensive, short-term sampling of some variables. This may need to be continuous (or very frequent) for such parameters as light, TSS, turbidity, and chlorophyll a. A possibility might be a series of intensive 1 to 3 day continuous stations spaced throughout the year at places that need special attention. This could be coupled with simultaneous intensive biological monitoring.

## PARAMETERS MEASURED

Again, consistency is needed in the selection of parameters to be measured. The CBP was hampered by some studies measuring only inorganic nutrients, others only part of a suite of organics, etc., and so on. The CBP found TN and TP to be the best indicators of change, but many very carefully done studies (e.g., CRIMP) did not measure these. A "core" set of parameters should be selected that will be measured each time.

There is a need for either consistency of methodology (e.g. EPA, APHA Standard Methods, biological recommendations such as those for phytoplankton contained in the Handbook of Phycological Methods) or some way of comparison. Winkler titration or an oxygen electrode type meter that is resistant to $H_2S$ poisoning should be used where anoxic waters are expected.

Variables should be measured using methodologies sensitive enough to identify expected ambient concentrations. This is particularly true of any toxicant monitoring; here one should be able to at least determine if EPA water quality criteria have been exceeded (i.e., level of detection should be less than the acute value, at least). If appropriate sensitivity is not attainable, alternate strategies, such as examination of animal tissue for bioaccumulation, may be recommended.

# ATTACHMENT 2

# HYPOTHESIS TESTING

Hypothesis construction and testing for each of the three living resources is discussed fully within the next few pages. Included in this discussion is a brief explanation of what was accomplished through the characterization process (Flemer et al. 1983) related to the questions asked.

## SECTION A

Questions and Hypotheses involving Management and Monitoring Strategies Concerning Oysters

Hypothesis #1: Variation in spat set recruitment is due primarily to variations in freshwater discharge and salinity during spawning and the early life stages of the oyster.

Rationale: Ulanowicz et al. (1980) have shown that success in spat set is correlated positively with high salinity and negatively with the previous year's harvest. Krantz and Carpenter (1981) report that the impact of Tropical Storm Agnes (1972) on oyster populations was largely responsible for a decrease in production and a shift in harvest from upstream of Cobb Island to the lower Potomac below Ragged Point-Piney Point. In addition there has been no significant oyster recruitment in the upstream estuarine portion of the Potomac river since 1965; this may well be due to increased freshwater flows during the last decade. Biggs (1981) has suggested that ancestral oyster reefs in the upper main-stem of the Chesapeake provide evidence that oysters once inhabited the upper reaches of the Chesapeake tributaries before deforestation of the watershed created a more variable pattern of runoff where peak flows may be 30 percent greater today than prior to deforestation.

Answers from Characterization: Davis et al. (1981) have reported high oyster spat sets for the years 1980 to 1981 in the Chesapeake Bay area. The highest spat sets were in the lower Bay, particularly on the Eastern Shore in a pattern that reflects the pattern of highest salinities in the area. The trend toward increasingly light spat set in less saline reaches has been documented in detail for the Potomac River (Krantz and Carpenter 1981, Flemer et al. 1983). While spat set in the lower Potomac has continued to vary in response to salinity, set in the middle and upper Potomac has been suppressed since the late 1960's. These areas showed no increases during 1980. However, we have not yet attempted to demonstrate a statistically verified relationship with salinity in our analyses.

Approach: Select test estuaries on the Eastern Shore and western shore that have comparable spawning populations, and geomorphological and hydrographic regimes. Spat collectors spaced at intervals over the average range of salinities from 5 to 20 ppt, compare spat set success at equal salinity exposures in each tributary. If salinity is the controlling factor, spat set success should be statistically the same in equivalent salinity segments in each of the eastern and western tributaries. If other factors are controlling, spat set may not be the same in equivalent salinity segments.

Verification of these field studies by laboratory spat-set studies using the same salinity exposures is desirable.

Hypothesis #2: Variation in spat set recruitment is due primarily to variations in sedimentation rates and reduction in settling substrate.

Rationale: Galtsoff (1964) and others have shown that oyster larvae preferentially set on clean hard substrate (usually oyster shell). Substrate laden with sediment or fouling organisms prohibits successful setting. Indeed, shell-planting for oyster production enhancement is desirably timed to coincide with the peak larval swarm to avoid sedimentation and fouling of the substrate.

Biggs (1981) has shown that peak runnoff generated flows in the tributaries of the Chesapeake are on the order of 30 percent higher than before deforestation. This rapid runoff of the estuary undoubtedly increases the suspended solids loads and pushes the turbidity maximum further downstream.

In addition, Ulanowicz et al. (1980) have shown that success in spat set is negatively correlated with the previous year's harvest which contributes to the removal of substrate.

Answers from Characterization: Removal of substrate (by harvest) has lowered the profile of many oyster bars; that is, they are closer to the sediment surface (Marshall 1954). This makes them more vulnerable to sedimentation. As discussed in Chapter 1, sediment transport and deposition into Chesapeake Bay has increased dramatically in the last 150 years. Existence of extensive buried oyster beds where substrates are now unsuitable is an indication of sedimentation effects (Alford 1968). Sediment also affects recruitment; a few mm of sediment on shell may prevent setting of spat (Galtstoff 1964). However, there are insufficient data on sediment distribution and loading in the water column to allow for a statistical analysis of this perceived problem.

Approach: Select test estuaries that have comparable spawning populations, geomorphological, hydrographic, and water quality regimes but that differ in suspended sediment load. Using spat collectors, compare spat set success at equal salinity exposures but with different sediment loads in each tributary.

Verification of these field studies by laboratory spat set studies using the same sediment exposures is desirable.

Hypothesis #3: Variation in spat set recruitment is due primarily to variations in levels of toxic materials in oyster growing areas of Chesapeake Bay.

Rationale: Evidence from the U.S. Environmental Protection Agency's Chesapeake Bay Program "Survival Envelope" analysis indicates that the tolerance levels of oyster eggs and larvae are exceeded in several locations by certain heavy metals and other toxic materials. Although cause-and-effect cannot be shown statistically, there is cause for concern.

Answers from Characterization: Comparison of EPA water quality criteria to measured and estimated concentrations of toxicants in the water column reveal a number of instances where these criteria are exceeded (Chapter 2). Oyster larvae are relatively sensitive to copper and mercury, while adults are sensitive to cadmium (Kaumeyer and Setzler Hamilton 1982). Thus, although direct cause-and-effect cannot be demonstrated, occurrence of relatively high levels of toxicants in the water column near oyster beds would be cause for concern.

Accumulation of heavy metals by oysters was described by Ayling (1974). He found chromium and copper to be adsorbed to a weight proportional to, and limited by, the size of the oyster and apparently independent of sediment concentration. Cadmium and zinc were accumulated in proportion to their concentration in the sediment. Lead was concentrated randomly at sites containing high sediment lead concentrations.

Mean levels of cadmium, copper, and zinc in oyster tissues from Chesapeake Bay were compared to the sediment contamination factors ($C_f$) for each metal, using the Spearman rank correlation coefficient. Levels of zinc in shellfish tissue correlated at $p<0.01$ with zinc in bed sediment, in agreement with Ayling's findings. Copper levels in oyster tissue were also positively correlated with sediment concentrations ($p<0.01$). Tissue concentrations could not be related to size of the organisms because tissue analysis had been performed on composite samples of various sized oysters. No statistical relationship could be demonstrated between cadmium in oysters and that in sediments although levels of both tend to be low in Mobjack Bay, the Potomac, and the upper main Bay.

Approach: Water samples would be collected from good and poor setting areas. Salinities of one set of samples would be adjusted uniformly to the highest field salinity by the addition of "artificial sea salts" to the low salinities; conversely, another set of samples would be adjusted to the lowest field salinity by dilution of higher salinities with distilled water. All living material in these samples would be killed by acidification and neutralization and the samples would be innoculated with algae known to be nutritious to oyster larvae. Salinity and food standardization are intended to eliminate these factors as variables in the experiment, leaving only the concentration of toxic materials in the bioassay water as a variable. Oyster eggs would be cultured in these samples to setting using controlled environmental mariculture techniques (Bolton 1982).

Parameters used to determine the relative quality of the water from the various samples would include but not be limited to mortality of eggs, improper larval development, mortality, and growth of larvae and setting success.

Samples showing poor water quality through this bioassay would be analyzed for toxic components. Once identified, a synthetic medium consisting of these components would be retested to verify the bioassay results.

Hypothesis #4: Variation in spat set recruitment is due primarily to nutrient loading and oxygen depletion.

Rationale: Evidence from the U.S. Environmental Protection Agency's Chesapeake Bay Program analysis of oyster landings indicates that lower production occurs where nutrients (TN) are highest in the Bay. This could possibly be due to a shift in phytoplankton species composition that could provide less palatable and nutritious food for the oyster or to $O_2$ depletion in deeper water that could reduce the available growing area.

Answers from Characterization: Nutrient enrichment may cause shifts in phytoplankton species to forms less suitable for oyster food. Ryther (1954) reported a case where runoff from duck farms produced excessive nutrients in Moriches Bay, Long Island, New York; a predominantly diatom flora was replaced by a small non-motile green algae. These were not usable by oysters for food, so the local oyster fishery declined precipitously. It is well-documented that all algae are not equally suitable for oyster food (Walne 1963, 1970). Eutrophication often results in blooms of types considered less desirable: bluegreens, non-motile greens, and dinoflagellates (Ryther and Officer 1981). Bluegreens are not generally a problem in saline areas where oysters are found. However, in some coastal regions, blooms of certain dinoflagellate species are the cause of episodes of paralytic shellfish poisoning (PSP); the dinoflagellate blooms themselves have been related to nutrient enrichment of coastal waters, at least in some areas (Prakash 1975).

In Chesapeake Bay, there is relatively little data to provide evidence that significant changes in phytoplankton community structure have taken place in oyster-growing areas (See Chapter 2, Flemer et al. 1983). Although blooms of dinoflagellates occur frequently, these are not species known to be toxic or to cause PSP (Mackiernan 1968). However, continued monitoring of phytoplankton communities, and comparison to historical data is recommended.

As with benthic organisms in general, the strongest link to nutrient enrichment is probably through dissolved oxygen. Oyster larval growth ceases at 1.7 ml $L^{-1}$ dissolved oxygen, and adult oysters close up when levels reach 0.7 ml $L^{-1}$ or less. During this time, they undergo anaerobic metabolism, which is energetically costly. In warm summer months, oysters can survive about five days in this manner; if anaerobic conditions persist much longer, they will die (Kaumeyer and Setzler-Hamilton 1982). In many areas of the Bay, oysters are restricted to depths less than 10 m by low oxygen (Haven et al. 1981). Increased mortalities of oysters observed in recent years may be due to intrusion of hypoxic water into shelf areas. [1]

1980 Landings of all commercial finfish and shellfish were compared to nutrient concentrations for the most recent year of record. A significant inverse relationship ($p < 0.01$) was found between shellfish and mean annual total nitrogen (i.e., high nitrogen values were correlated with low harvest.) This relationship was apparently mostly due to oysters: a significant inverse relationship ($p < 0.05$) existed between 1980 oyster harvest and total nitrogen. (In making this comparison, the Chester River was omitted due to its recent unexplained oyster mortality). Such a relationship could be due to low dissolved oxygen impacts, food web shifts, or both.

Approach: Select test estuaries that have comparable geomorphological, suspended sediment and hydrographic regimes but that differ in ambient levels of nutrients. Sample phytoplankton, suspended and dissolved organics, $O_2$ levels at various depths, and suspended sediment loads during the growing season (summer). Identify quantitative and qualitative differences in the parameters measured and loss of growing area due to $O_2$ depletion.

Verify field studies in laboratory feeding and growth studies using simulated field conditions through controlled environment mariculture techniques.

Hypothesis #5: Disease, parasites, and predators have more influence on distribution and abundance of oysters than does water quality.

Rationale: In many situations oysters are restricted from high salinity areas due to predators (starfish, drills, etc.), parasites (Buchephalus, Polydora, etc.), and diseases (MSX, Perkinsus marinus, etc.) (Flemer et al. 1983). In addition, Sindermann (1980) indicates that a number of diseases (particularly viral types) are thought to express themselves after exposure to pollutant stress (Farley et al. 1972).

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[1] Personal communication: "Effects of Dissolved Oxygen on Oysters", G. Krantz, MD DNR, 1982.

**Answers from Characterization:** It is well known that MSX and other high salinity predators and diseases intrude further into the Bay during droughts (as in the late 1950's and early 1980's) and have reduced oyster production accordingly. Synoptic data are currently being gathered to allow a quantitative assessment of the magnitude of the impact of disease.

**Approach:** It will be important to continue routine condition assessment and pathological examinations of oyster samples (conducted in the manner of the current Maryland Department of Natural Resources oyster pathology survey) based on an experimental design that allows one to determine whether condition and pathology are the result of pollution stress or are the primary factors affecting distribution and abundance of oysters.

**Hypothesis # 6: Rationale:** Abundance cycles of fish and shellfish in Chesapeake Bay and its tributaries are strongly affected by fishing pressure. The literature is replete with examples of the effects of over-fishing on fishery stocks (Cushing 1975, Flemer et al. 1983).

**Answers from Characterization:** With the exception of a few carefully studied fisheries in Chesapeake Bay (e.g., the Atlantic menhaden), it is extremely difficult to predict that levels of over-fishing and fisheries landings (catch) cannot be related to species abundance because the effects of fishing effort, reporting error, and market demand are essentially unknown and cannot be adjusted for using historically collected statistics. (Although effort statistics are now typically being collected, the period of record is short.)

**Approach:** Use the recently implemented fishing effort reporting system using catch per unit effort statistics that allows one to separate the fishing mortality from both sports and commercial fishing from natural mortality. Standardize, refine, and extend the Maryland and Virginia juvenile finfish surveys and spat set surveys to allow for a reasonably accurate prediction of natural mortality and success of recruitment to the fishery. In addition, calibrate spat set index and catch statistics with field sampling programs that provide some indication of the usefulness and precision of these parameters as measures of abundance.

## SECTION B

### Questions and Hypothesis Involving Submerged Aquatic Vegetation (SAV)

**Hypothesis # 1:** There has been a continuous and progressive Bay-wide decline in the abundance of SAV.

**Rationale and answers from Characterization:** Historically, submerged aquatic vegetation has been abundant throughout the estuary. However, a dramatic reduction in the distribution and abundance of SAV has occurred since about 1965. This decline was first observed in the upper Bay and fresher reaches of tributaries, and has progressed down-estuary. Submerged aquatic vegetation now occupies a significantly more restricted habitat than previously. As a consequence, its role in Bay ecosystem processes has also been reduced, and its ability to recover from its current status is uncertain (Flemer et al. 1983).

Specific Question: What is the year-to-year area extent of SAV coverage in the Bay?

Approach: Aerial photography has been used in the past for this type of survey (e.g., Orth and Moore 1982). However, this method is costly and time-consuming. It is suggested that the possibility of remote sensing by satellite be seriously investigated. In addition, computer comparison of photographs can be done to delineate areas of non-overlap from one year to the next--that is, areas where a change in the SAV beds has occurred. Monitoring at wider intervals than one year is possible, but the rate of change of some beds has been so rapid that this may be too infrequent to allow identification of "trouble areas" before irreparable change has occurred. Further analysis and monitoring recommendations are provided in Attachment 8.

Hypothesis # 2: There is a decline in diversity of SAV in Bay, particularly in the upper Bay.

Rationale and answers from Characterization: Beds of vegetation in fresher areas of the Bay were characteristically very diverse, with up to 10 species represented. During the past 15 years, the distribution of all species has declined; some forms, probably the most sensitive, have been virtually eliminated. Remaining SAV populations are primarily characteristic of the higher-salinity forms. Relatively little SAV characteristic of tidal-fresh and oligohaline waters remain, and these populations are chiefly confined to small tributary creeks and headwaters of some rivers (Flemer et al. 1983).

Specific Question: What are the major SAV species represented in selected areas?

Approach: A 650-station survey of SAV has been conducted annually by Maryland Department of Natural Resources and the USFWS since 1971. This survey determines the percent of vegetated sites in each survey area, and the species present. A similar field program would be needed to monitor species composition of SAV beds. Fewer sites, Bay-wide, could be selected for long-tem monitoring. This should include important physical parameters, as well as biological ones. (See following question). Areas selected should be ones with representative SAV beds, ideally with some historical data for comparison. In addition, a few areas which once supported abundant SAV but are currently denuded should be monitored. Sites from the EPA's CBP studies (e.g., Seneca Creek, Mumfort Island, and Vaucluse Shores) should be among those monitored.

**Hypothesis # 3:** Light limitation on SAV caused by increased water column turbidity, epibiota on SAV fronds, or both is a major cause of the decline.

**Rationale and answers from Characterization:** EPA's CBP sponsored research on SAV concluded that the quantity of light reaching SAV has declined in recent years, and that quality (that is, the amount in the photosynthetically active range) has also declined. This is believed due, at least in part, to increased phytoplankton biomass resulting from nutrient enrichment. In addition, nutrient enrichment has also been shown to lead to greater fouling of SAV fronds with epibiota. This can significantly reduce the amount of light reaching the leaf surface.

*In situ* studies indicate that Bay plant communities are generally operating under conditions of light limitation. Mesocosm (pond) experiments found that nutrient loading leads to increased phytoplankton biomass, suspended particulate, and epiphytes. This markedly reduced SAV photosynthesis. Loss of SAV occurred in ponds exposed to highest nutrient concentrations.

**Specific Question:** What is the range of turbidity over SAV beds; what is the seasonal change in abundance of epibiota on SAV? How can photosynthesis, growth, and biomass of SAV bed be related to these light attenuation factors?

**Approach:** Representative sites should be selected in different areas of the Bay with different major plant communities (i.e., *Potamogeton*, *Zostera/Ruppia*, or *Vallisneria* - dominated). The following parameters should be monitored: light transmission or attenuation over SAV bed, suspended sediment (over a tidal cycle); water column chlorophyll *a*, suspended solids, TOC, nutrients; wet weight or dry weight epibiota per unit area or weight SAV; density of SAV, biomass per unit area (shoot and root); ideally, measure of SAV photosynthesis or production should be taken.

This monitoring needs to aid in the understanding of the diurnal cycle of light and suspended material over an SAV bed in different areas of the Bay, under a variety of wind and wave conditions. What is the range? Also, needed is an understanding of the seasonal nutrient concentrations, chlorophyll *a* concentrations, epibiota biomass, SAV density, biomass, and growth rate.

**Hypothesis # 4:** Increased amounts of herbicides are being carried in runoff to Bay tributaries; these can impact SAV communities if concentrations reach critical levels.

**Rationale and answers from Characterization:** The use of agricultural herbicides has increased significantly in the recent decade. Atrazine and linuron, the two most common forms, affect the photosynthetic process. Plants exposed to herbicides show a rapid reduction in photosynthesis followed -- in the case of low herbicide concentrations -- by gradual recovery. The higher the initial exposure, the longer the recovery time. Plants exposed to 10-15 ppb atrazine took two to five weeks to regain a photosynthetic rate comparable to controls, while plants treated with 50 ppb atrazine and above did not recover.

Field observations rarely found herbicide concentrations above 5 ppb, and never above 20 ppb, in estuarine waters. Much higher levels (up to 100 ppb) were observed in small tributaries adjacent to treated fields, immediately following rainstorm events. Herbicides degrade relatively rapidly and do not appear to build up in sediments. (However, relatively little is known about toxicity of major degradation products.)

Because very low concentrations of herbicides (less than 10 ppb) are predicted to cause a reduction of 10 to 20 percent in SAV photosynthesis, and because herbicide use is increasing, these toxicants should continue to be monitored. This is particularly true in areas that are light-limited, and where plants are not photosynthesizing at maximum rates.

Specific Question: What are ambient herbicide concentrations at selected sites? What is the 30-day range of the herbicide and degradation product concentrations? What is the frequency of runoff events leading to herbicide contamination of near-field waters?

Approach: Continue to monitor herbicide concentrations at selected areas where effects are expected to be observed. Simultaneously, SAV abundance, biomass, and growth should be observed. Consideration should be given to effects on young plants, sprouting in spring, and seedling survival.

Monitoring should be designed to give a picture of long-term levels of herbicides, over a 30-day period, for example. Frequency, intensity, and duration of rainfall events, and timing of herbicide applications should also be measured.

## SECTION C

### Questions and Hypotheses Involving Freshwater-Spawning Finfish

Striped Bass: The striped bass will be used as an example for this important group of fish.

Hypothesis #1: Striped bass eggs and larvae show a differential response to water quality variables associated with their natural-spawning habitat.

Rationale and answers from Characterization: The CBP's environmental characterization reported numerous times where Cd levels exceeded the 96-hour $LC_{50}$ level for striped bass larvae and juveniles. The widespread use of chlorine biocide suggests that it too should be examined as a potential hazard. The Emergency Striped Bass Program administered by the U.S. Fish and Wildlife Service and the

National Marine Fisheries Service has obtained evidence that indicates synergistic effects of water quality factors, probably metals and possibly synthetic organic chemicals, may be responsible for chronic toxicities and behavioral changes in the larvae[2]. Because the striped bass population has declined to very near historic low levels in the Bay (based on landings data), it is important to further assess the relationship between water quality and survival of striped bass larvae and juveniles.

Approach: Striped bass, preferably hatchery stock, from a known Bay genetic stock, should be used in 96-hr or longer bioassays utilizing tidal-fresh to brackish water from major spawning sites (e.g., upper Bay, Potomac, Nanticoke, Choptank, James, York and Rappahannock). It is important to include a number of ecologically and biologically meaningful end-points (e.g., death) change in the activity of a physiological and biochemical factor, or behavior such as feeding and pathologies. Several significant effects may occur at 1/10 of $LC_{50}$ after long periods, it is important to run low level, long-term bioassays.

Reference experiments should be made utilizing appropriate uncontaminated water. Control of experimental variance should be a priority item. Operational considerations may involve one or more mobile trailer units and microcosms should be considered. Seasonal studies should be run (e.g., April, June, and September). Water chemistry analyses should consider metals, and "organic finger-prints". These data need to be taken from the water associated with the bioassay work.

Hypothesis #2: Rationale and answers from Characterization: Striped bass larvae and juveniles are limited by the quality and quantity of zooplankton available as food. Striped bass larvae show a selectivity for larger zooplankton and appear to have a threshold to begin first feeding (Kaumeyer and Setzler-Hamilton 1982). Because zooplankton are known to be variable in their distribution and abundance, it is suspected that the density and extent of the zooplankton may be significant to the successful feeding and survival of larvae and juveniles. There is evidence that zooplankton, especially *Eurytemora affinis*, an important food of striped bass larvae, feed on detritus in early spring (Heinle and Flemer 1975). Heinle et al. (1976) suggested that availability and timing of detrital food input may limit production of zooplankton and ultimately striped bass.

Approach: Several major tributary streams (e.g., the Potomac, upper Bay, Nanticoke and Rappahannock Rivers) should be studied. Verificiation of types of food eaten by the striped bass larvae should be made. Corollary data such as indices of physiological state (i.e., DNA/RNA ratios, lipid ratios and morphological condition, including eye pigment anomalies, and vertebral column deformities) should be measured and compared to type and abundance of food in each estuary.

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[2] Personal communication: "Behavioral changes in striped bass larvae caused by toxic substances", Paul Mehrle, NOAA/NMFS 1982.

An important distinction should be made in this assessment between changes in standing stocks and turn-over times. The latter can be estimated most appropriately through laboratory studies.

Spatial and temporal scales are very important in the assessment of this problem. Special consideration should be given to the heterogenous distribution of zooplankton. Because the input of detrital material is likely associated with river flow and winter temperature, it is important to have a complete time series of these variables. Grazing by zooplankton may prevent the development of well-defined patches of phytoplankton; thus, synoptic sampling of zooplankton and phytoplankton must be made for an adequate test of the primary hypothesis.

Hypothesis #3: Climatic variables correlate significantly with the abundance of striped bass juvenile success and landings.

Rationale and answers from Characterization: The following references explain the statistical relationships between climate and juvenile success and landings: Mihursky et al. 1981; Flemer et al. 1983, Ulanowicz et al. 1982.

Approach: Further monitoring of the climatic variables with reference to striped bass juveniles is important to the possible identification of causative relationships. Much of the required physical data would be collected under the baseline effort. Information on the effects of wind in the upper Bay may be important on C and D canal circulation because there is a possibility of net transport of larvae and juveniles toward Delaware Bay.

Hypothesis #4: Striped bass may be limited in available habitat by the encroachment of the anoxic layer or low dissolved oxygen levels in the deep channel and lower shelf of the Bay.

Rationale and answers from Characterization: In reservoirs, cool water is found only at depth in summer; these layers are also often oxygen depleted. There is evidence that striped bass in such reservoirs seek the cooler water and consequently become stressed by low DO levels (Coutant 1980). The potential for a similar problem may exist in the Bay (Flemer et al. 1982). However, data on striped bass distribution in the Bay relative to low DO levels is undocumented.

Approach: The magnitude, geographical extent, and duration of the anoxic layer, including levels less than 4 mg $L^{-1}$ of dissolved oxygen, should be monitored from March through

October. Coincident with this monitoring, the following variables should be included: temperature and salinity profiles, freshwater flow and wind vectors. Much of this information should be collected as part of the environmental baseline.

A very difficult but important estimate is the development of data on the vertical distribution of striped bass. Possibly some remote sensing through sonic tagging might be feasible.

**Hypothesis #5:** Striped bass numbers may be limited through predation by abundant bluefish.

**Rationale and answers from Characterization:** It is important to understand the hypothesized relationship because the size of the striped bass population may be controlled by a water-quality factor that is manageable, but their population recovery may not occur if the predator-prey balance is changed (Skud 1982).

**Approach:** Survey the impact of bluefish as predators, directly on striped bass and indirectly on the food of striped bass. Correlations over time with the abundance of bluefish and striped bass should provide evidence to test the hypothesis.

**Hypothesis #6:** Striped bass stocks are strongly affected by fishing pressure.

**Rationale and answers from Characterization:** An understanding of this relationship is fundamental to effective management of striped bass stocks. Fishery biologists have long recognized the uncertainty associated with making inferences about stock size based on landings data. Such data may not accurately characterize even where the fish are caught.

**Approach:** Improvement in data on catch per unit effort is a useful and cost-effective first step. Landings data adjusted for catch per unit effort should correlate better with the juvenile index. Consideration must be given to commercial and recreational fishing.

# ATTACHMENT 3

## SUMMARY OF PRESENT MONITORING ACTIVITIES

### AGENCIES AND INSTITUTIONS

The following is a list of all the state and Federal agencies, and research and educational institutions included in this attachment.

## SECTION A

### STATE MONITORING

1. State of Maryland (Table 3a.1)
    a. Maryland Department of Natural Resources (DNR)
        1) Tidewater Administration (TA)
        2) Power Plant Siting Program (PPSP)
    b. Maryland Department of Health and Mental Hygiene
        1) Office of Environmental Programs (OEP)
        2) Water Resource Administration (WRA)
2. State of Virginia (Table 3a.2)
    a. State Water Control Board (SWCB)
    b. State Health Department (SHD)
        1) Bureau of Shellfish Sanitation (BSS)
    c. Hampton Roads Sanitation District (HRSD)

## SECTION B

### FEDERAL AGENCIES(Table 3b.1)

1. National Oceanographic and Atmospheric Administration (NOAA)
2. United States Geologic Survey (USGS)
3. United States Fish and Wildlife Service (USFWS)

## SECTION C

### DISTRICT OF COLUMBIA (Table 3c.1)

## SECTION D

### OTHER STUDIES (Table 3d.1)

1. Chesapeake Bay Institute, John Hopkins University (CBI)
2. Virginia Institute of Marine Science (VIMS)
3. Anne Arundel Community College (AACC)
4. Chesapeake Biological Laboratory, University of Maryland (CBL)
5. Horn Point Environmental Laboratories (HPEL)

6. Old Dominion University, Virginia (ODU)
7. Martin-Marietta Corporation (MMC)
8. Smithsonian Institute, Rhode River (RR)
9. Academy of Natural Sciences, Philadelphia (ANSP)
10. Baltimore Gas and Electric (BG&E)
11. Potomac Electric Power Company (PEPCO)
12. Energy Research and Development Administration (ERDA, now DOE)

TABLE 3a.1. STATE OF MARYLAND MONITORING

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Water Quality<br>(CORE) | OEP | DO, pH, Temp., TOC, TDS, Conductivity, TSS, $NH_3$, $NO_2$+$NO_3$, TN, TKN, TP, T. Ortho P, Turbidity, T. Coliform, Fecal Coliform, Chlorophyll a, Phaeopigments, Alkalinity | Monthly | 1979-present* | 7 stations |
| Macrobenthic Invertebrates | OEP |  | 1/year<br>May - Aug. |  | 155 stations |
| Plankton | OEP | Phytoplankton |  |  | 14 stations |
| Juvenile Index | DNR | Species ident. and enumeration. Length and age distribution Air temp., salinity, depth, range, weather conditions, tide stage | Monthly during July-Sept.<br>2 samples per station | 1954-present | 22 stations, 100 ft. beach sein, 1/4 inch bar mesh. Additional stations are added for survey validation. |
| Oyster Spat | DNR | Macroscopic condition #'s of spat per bushel temp., salinity | Annually during fall; more frequently when MSX threatens | 1937-present | 60 stations, tongs |
| Oyster Condition | DNR | Macroscopic and Microscopic inspect.for disease | Annually or up to 4 times/yr. | 20 years | 40-50 stations, tongs or hand scrape, random pick of 25 per station |
| Fish Condition | DNR | Macroscopic and Microscopic inspect. for disease | 2 times/yr. | 1982-present | Associated research and bioassay. |
| Striped Bass Stock Assessment | DNR | Stock asses., age, sex, migration, fecundity, egg, and larval abundance, fry movement and recruitment index. | Continuous- | 1918-present | Upper Bay, Choptank River. |

*present = 1982

TABLE 3a.1. (continued).

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Shad Stock Assessment | DNR | Same as striped bass | daily | 1980-present | Upper Bay Region - daily stock measurements. |
| River Herring Assessment | DNR | Same as striped bass | daily | 14 years | |
| Shellfish Contaminants (Oyster, clams) | OEP | Heavy metals, PCB's, pesticides, sal., temp., pH, DO, Cu, Zn, Pb, Hg, As, Cd, Cr, PCB 1254, PCB 1260, PCB 1242, Lindane, BHC, DDE, DDT, DDD, Dieldrin, Endrin, Aldrin, Dacthal, Mirex, Toxaphene, Methoxychlor, Endosulfan, Hexachlorobenzene, Heptachlor epoxide, Heptachlor Chlordane | 2/year sp, fall | late 1960's | 82 stations |
| Fish Tissue | OEP<br>DNR | See above (Shellfish Cond.) | 1/year | | 9 stations (2 or 3 samples per station)<br>Shock, trap, travel |
| Compliance | OEP | | 24 hr proportional composite sample for every outfall permitted | 1979-present | At discharge points. To ensure that NPDES discharge permit conditions are being followed |
| Submerged Aquatic Vegetation | DNR, USFWS | Species ident. water depth, surface salinity, surface water temp., Secchi disk. | Annually | | Approximately 650 stations |
| Radiological-Biota and Sediments | MD/PPSP | Gamma, Sr 89/90 | Quarterly to annually (varies) | Varies depending on group of biota. Some since 1974. | Vicinity of Peach Bottom and Calvert Cliffs Power Plants |

TABLE 3a.2. STATE OF VIRGINIA MONITORING

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| EPA Core Monitoring Network: Water | SWCB | As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Ca, Fe, Mg, Mn, Na, K, Pesticide/ Herbicide Scan | Annually | 1979-present | 9 stations |
| Water Quality | HRSD | Salinity, Temp., TP, Ortho P, Nitrate, Nitrite, Ammonia, Organic N, TSS, Volatile-SS, Total Residual Chlorine, $BOD_5$, pH, Secchi depth, Fecal Coliform | One cruise per season (fall, winter, spring) | 1979-present | 23 stations in the lower James an 23 in the York Rivers; surface and bottom samples |
| Ambient Water Quality | SWCB | DO, pH, weather, Temp., Flow severity, TKN, TP, Orthophosphorus, Ammonia, Nitrate, Nitrite, TSS, Volatile-SS, Fixed-SS, $BOD_5$, COD, Fecal Coliform, conductivity | Monthly | 1955-present | 73 stations |
| EPA Core Monitoring Network: Sediment | SWCB | As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, Ca, Pesticide/ Herbicide Scan | Semi-annually | 1979-present | 9 stations |

TABLE 3a.2. (continued)

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Sediment | HRSD | pH, Cu, Cd, Pb, Zn, Hg, Total organics, particle size, % volatile solids, organic N, ammonia, TP, Redox potential, macroinvertebrate species composition and biomass; pesticides and PCB's once per year | Semi-annually | 1979-present | 46 stations |
| Sediment | SWCB | Kepone | Annually | 1976-present | 34 sediment stations |
| EPA Core Monitoring Network: Fish Tissue | SWCB | As, Cd, Cr, Cu, Pb, Hg, Ni, variety of pesticides and herbicides | Annually | 1979-present | 9 stations |
| Fish Tissue | SWCB | Kepone | Quarterly | 1976-present | James River estuary 6 finfish stations (was 12 initially) |
| Oyster Growing Areas | SHD - BSS | Fecal Coliform, MPN, and standard plat count | As needed | 1960-present | |
| Oyster Tissue | SHD - BSS | Cadmium, copper, zinc, pesticide/herbicide scan | Semi-annually (spring-fall) | Metals: 1972-present<br>Pesticides: late 1960's-present | 40 metal stations and 27 pesticide stations, Bay-wide in oyster harvesting areas |
| Special Kepone Monitoring in Oysters and Crabs | SHD - BSS | Kepone | Monthly for crabs; spring and fall for oysters | 1976-present | 15 stations: 7 oyster, 8 crabs, additional random samples from dealers |

TABLE 3b.1. FEDERAL MONITORING

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Meteorological | NOAA | Air temp., dew pt., barometric pressure, wind sp. and direction, clouds, visibility, rainfall, hrs. of sun | 3 hr. synopsis aviation hourly, climatic summary at end of day, monthly summary | continuous during various study periods 1981-1983 | 8 stations in immediate Bay region |
| Current | NOAA | Current direction, speed, depth, conductivity, temperature, pressure | | 1981-1983 | 63 moored current meter stations; (4) long-term stations, (3) 60-day, (1) 45-day, (42) 30 day, (13) 5-day stations |
| Tide | NOAA | Tide height, salinity, water temperature | | 1981-1983 | 7 control tide stations,<br>13 subordinate tide stations |
| Discharge | USGS | Streamflow (cfs) | daily | 1923 to present<br>1978 to present<br>1907 to present | 42 stations (MD)<br>33 stations (VA) |
| Discharge (chemical, micro-biological, and water temp., metals) | USGS | see footnoted page of parameters | discharge & water temp (daily), water quality at least monthly | 1907 to present | Metal conc. sampled less frequently at selected stations<br>11 stations in immediate Bay vicinity |
| Pesticide | USFWS | see attached | biannual in fall | 1969 to present | 3 stations: Susquehanna, Potomac, James Rivers, 3 individual from target species of predator and bottom feeders |
| Water Quality | USGS | DO, pH, Temp., Conductivity. (Tide, sal. and solar rad. before 1979) | Continuous | 10 years | Monitoring of WQ in Rhode River estuary at Contee's Wharf begun by Bob Corey (USGS retired) |

## Parameters from U.S. Fish and Wildlife Service for Table 3b.1

Species, average weight, average length, lipids, moisture, DDE, DDD, DDT, Aroclors, Toxaphene, Dieldrin, Aldrin, Endrin, α BHC, BCB, Heptachlor, Heptachlorepoxide, Cis-chlordane, Trans-chlordane, Cis-nonachlor, Trans-nonachlor, Lindane, Dacthal, oxychlordane, total DDT, Aldrin-dieldrin, Total PCB, Heptachlor-Heptachlor epoxide.

## Parameters from USGS for Table 3b.1

Physical Parameters--

Streamflow, specific conductance, pH, air temp., water temperature, turbidity, DO.

Inorganic Parameters--

Hardness, noncarbonate hardness, diss. Ca, diss. Mg, diss. Na, % Na, Na adsorption ratio, diss. K, diss. $K_{40}$, alkalinity, diss. $SO_4$, diss. Cl, diss. F, diss. Si, solids residue at 180 °C, sum of diss. solids constituents, diss. solids (tons/day and tons/ac-ft), solids residue at 105 °C, total nitrate, diss. nitrate as N, diss. nitrate as $NO_3$, total nitrite, diss. nitrite as N, diss. nitrite as $NO_2$, diss. $NO_2 + NO_3$ as N, total ammonia as $NH_4$, total organic N as N, diss. organic N as N, total ammonia + organic N as N, total ammonia + organic suspended N as N, ammonia + organic dissolved N as N, total N as N, diss. N as N, total N as $NO_3$, total P, total phosphate as $PO_4$, total phosphorus as $PO_4$, dissolved P as P, total orthophosphorus as P, diss. orthophosphorus as P, diss. orthophosphate as $PO_4$, and the total recoverable, suspended recoverable, and diss. concs. of Al, As, Ba, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, and Zn; total C, total organic C, diss. organic C, total inorganic C, diss. organic C.

Organic Parameters--

Volatile organics, PCB, Aldrin, Ametryne, Atratone, Atrazine, Chlordane, Cyanazine, Cyprazine, DDD, DDE, DDT, Dieldrin, Endosulfan, Endrin, Heptachlor, Heptachlorepoxide, Lindane, Methoxychlor, Mirex, Napthalenes (polyclor), Perthane, Prometone, Prometryne, Propazine, Simazine, Simetone, Simetryne, toxaphene; 2,4,-D; 2,4-DP; 2,4,5-T; Silvex

Biological Parameters--

Total phytoplankton, chlorophyll a, chlorophyll b, sus. sed., sus. sed. discharge (tons/day) and % susp. sed of sieve diameter <.062 mm. Fecal coliform and fecal streptococcus.

Radioactive Parameters--

Total sus. gross alpha, diss. gross alpha, total susp. alpha, total sus. gross beta, diss. gross beta, radium-226, diss. radon method, diss. uranium extraction.

TABLE 3c.1. DISTRICT OF COLUMBIA MONITORING

| Type of Monitoring | Agency | Station Group | Parameters | Frequency | Period of Record |
|---|---|---|---|---|---|
| Water Quality | DC | Close Interval Station | Conductivity, pH, dissolved oxygen, turbidity, water and air temperature, Secchi depth, tide state, cloud cover, wave height, incident light, wind speed and direction, fluorometric chlorophyll a, | monthly | 1982-present |
| | | Intercalary stations | Conductivity, pH, dissolved oxygen, turbidity, water and air temperature, Secchi depth, tide state, cloud cover, wave height, incident light, wind speed and direction, fluorometric chlorophyll a, $BOD_5$, TKN, Total and ortho-phosphorus, silica, alkalinity, fecal coliform | | |
| | | Full chemistry stations | Conductivity, pH, dissolved oxygen, turbidity, water and air temperature, Secchi depth, tide state, cloud cover, wave height, incident light, wind speed, and direction, fluorometric chlorophyll a, $BOD_5$, TKN, Total and ortho-phosphorus, silica, alkalinity, fecal coliform Total organic carbon, total dis. organic, carbon, total volatile sus. solids, sulfate, ammonia nitrogen, nitrate and nitrite, sol. phosphorus, chlorophyll and phaeophytin a, heavy metals, phytoplankton, total coliform fecal streptococci, total plate count | | |
| | | Continuous monitors | dissolved oxygen, water temperature. | | |

SECTION D

## OTHER STUDIES

In addition to the longer term monitoring of Bay conditions by Federal and state agencies, there are supplemental studies by independent and public research institutions which are mostly funded by Federal and state monies.

In Maryland, the Center for Environmental and Estuarine Studies (CEES) conducts research through four University of Maryland laboratories, three of them located on Bay waters (Chesapeake Biological Laboratory, Solomons, MD; Horn Point Environmental Laboratories, Cambridge, MD; Crisfield Laboratories, Crisfield, MD). Also located in Maryland is the Chesapeake Bay Institute of the Johns Hopkins University, which has conducted extensive research throughout the Bay since the 1950's. Anne Arundel Community College is conducting monitoring in the main Bay near Annapolis.

The Smithsonian Institution has conducted research through the Chesapeake Bay Center for Estuarine Studies at Edgewater, Maryland for over ten years, mostly around the Rhode River and Poplar Islands. Martin-Marietta Corporation's Environmental Center in Catonsville, Maryland has conducted benthic studies for the Maryland Department of Natural Resources since 1980.

In Virginia, the Virginia Institute of Marine Science (VIMS) has conducted extensive monitoring and research for the State Water Control Board. Old Dominion University of Norfolk has established a broad research and monitoring program in the lower Chesapeake Bay, the Elizabeth and James Rivers, and at near shore oceanic stations.

Some of the on-going projects of these agencies are briefly described in the following table. In most cases, final reports have not been submitted; therefore, complete information is tentative. Pertinent unpublished information is undoubtedly available through many agencies or individuals not listed, such as Bob Corey (USGS, retired) who has maintained a sampling station in the Rhode River for over 10 years, or St. Mary's College of Maryland, which conducts sampling through estuarine course-work and independent research studies.

TABLE 3d.1. OTHER MONITORING (ON-GOING)

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Water Quality and Plankton | CBI | Temp, sal, species, #'s | varied | N/A | |
| Water Quality, Sea Nettles Survey | CBL | Temp, sal, rainfall at lab, bottom and surface plankton and invert larvae | varies with season. At lease weekly in summer. | about 15 years | pkg parameters at lab, plankton and invert. survey in creek (otter trawls) |
| Water Quality Ambient, Toxic Disposal Site | ODU | see attached a & b | quarterly | 1981-present | numerous independent studies and sites |
| Sediment Quality | ODU | see attached | annually | 1980-present | numerous indep. studies and sites |
| Planktonic, Nektonic and Benthic Monitoring | ODU | meroplankton, benthic fishes, invertebrates phytoplankton composition and concentrations, macrobenthos, zooplankton | varied | | numerous indep. studies and sites |
| Benthic Community | CBL/ERDA/ANSP/ BGE/ (see attached d & e) NMC/PPSP | Abundance, biomass, sediment mechanical properties, sediment organic content, salinity, temp. DO at 3 meter intervals. | quarterly to 10 times/yr.<br>2 times/yr to monthly | 1970-present<br>1970-present | 17 stations near Calvert Cliffs.<br>16 stations near Morgantown.<br>7 stations near Main Bay.<br>16 stations near Patuxent. |
| Blue Crab Abundance | ANSP/PEPCO | Crabs | bimonthly May-Oct. | 1962-present | Patuxent River - trotlines at 8 stations near Chalk Pt. Generating Station. |

NA = Not available

TABLE 3d.1 continued

| Type of Monitoring | Agency | Parameters | Frequency | Period of Record | Comments |
|---|---|---|---|---|---|
| Water Quality, and Plankton, Nekton | Smithsonian Inst.,Rhode R. | Phy/nutr., plankton chlor a (weekly) milerotopic finfish |  | about 10 years | Dave Correll in Rhode R. estuary in conjunction with land runoff studies |
| Benthic Community Anadromous Fish | Smithsonian R R | juvenile fish, benthic infauna | Monthly | 1979-present |  |
| Slackwater Survey | VIMS | TKN, Nitrite, Nitrate, Ammonia, TP, Ortho P, Salinity, Temp., CBOD Chlorophyll | Monthly (June - October) | 1971-present | 80 stations, with surface, mid-depth, and bottom samples |
| Benthic Survey | VIMS | Species composition, sediment particle size | Quarterly | 1961-present | One station in York River off Gloucester Point |
| Juvenile Anadromous Fish Survey | VIMS | Species composition and relative abundance, length, weight, sex, gonad condition, age, spawning, mortality and growth estimates | Weekly (June, July, Aug.) | 1967-present | 16 stations - Mattaponi and Pamunkey Rivers; 2-3 hauls per 5 miles. Previously conducted in James, Chickahominy, Potomac, Rappahannock |
| Small Fish Survey | VIMS | # fish, wt/catch/ species, lengths, DO, Temp., surface and bottom salinity | Monthly | 1955-present | 18 stations Bay-wide |
| Blue Crab Juvenile Survey | VIMS | Counts of males, juvenile, and adult females | Monthly (May - November) | 1955-pres. York<br>1964-pres. James<br>1968-pres. Rapp. | 13 stations; 2 five-minute hauls at each station |
| Oyster Spatfall | VIMS | Spat #'s per bushel | Annually | 1947-present | 49 stations |

## Parameters measured from Old Dominion University for Table 3d.1

a. Water quality (surface and bottom measurements) samples: salinity, temperature, dissolved oxygen, turbidity, pH, suspended solids and volatile residue, chemical oxygen demand (COD), chlorophyll (a,b,c) and phaeophytin a, $NH_3$, $NO_2$, TKN, $PO_4$, total phosphorus (TP), metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn), chlorinated hydrocarbons (αBHC, Aldrin, Lindane, Heptachlor epoxide, Dieldrin, DDE, DDD, DDT, Endrin, Kepone, PCBs) and aromatic hydrocarbons (PNAs).

b. Toxin/bioaccumulation: metals (Cd, Cr, Cu, Hg, Ni, Zn, Pb), chlorinated hydrocarbons (αBHC, Aldrin, Lindane, Heptachlor epoxide, Dieldrin, DDE, DDD, DDT, Endrin, Kepone, PCBs), aromatic hydrocarbons (PNAs). Measurements made on organisms from three groups collected: demersal fishes, epibenthos, and zooplankton.

c. Sediment quality: metals (Al, Cd, Cu, Cr, Fe, Mn, Ni, Pb, Zn, Co), chlorinated hydrocarbons (αBHC, Aldrin, Lindane, Heptachlor epoxide, Dieldrin, DDD, DDE, DDT, Endrin, Kepone, PCBs), and aromatic hydrocarbons.

d. Total phytoplankton composition and supportive chlorophyll measurements.

e. Total fish, fish larvae, crab larvae, zooplankton, and benthic invertebrates.

## SECTION E

### MONITORING MAPS

Figures 3e.1 to 3e.16 show all state, Federal, and other monitoring stations by categories.

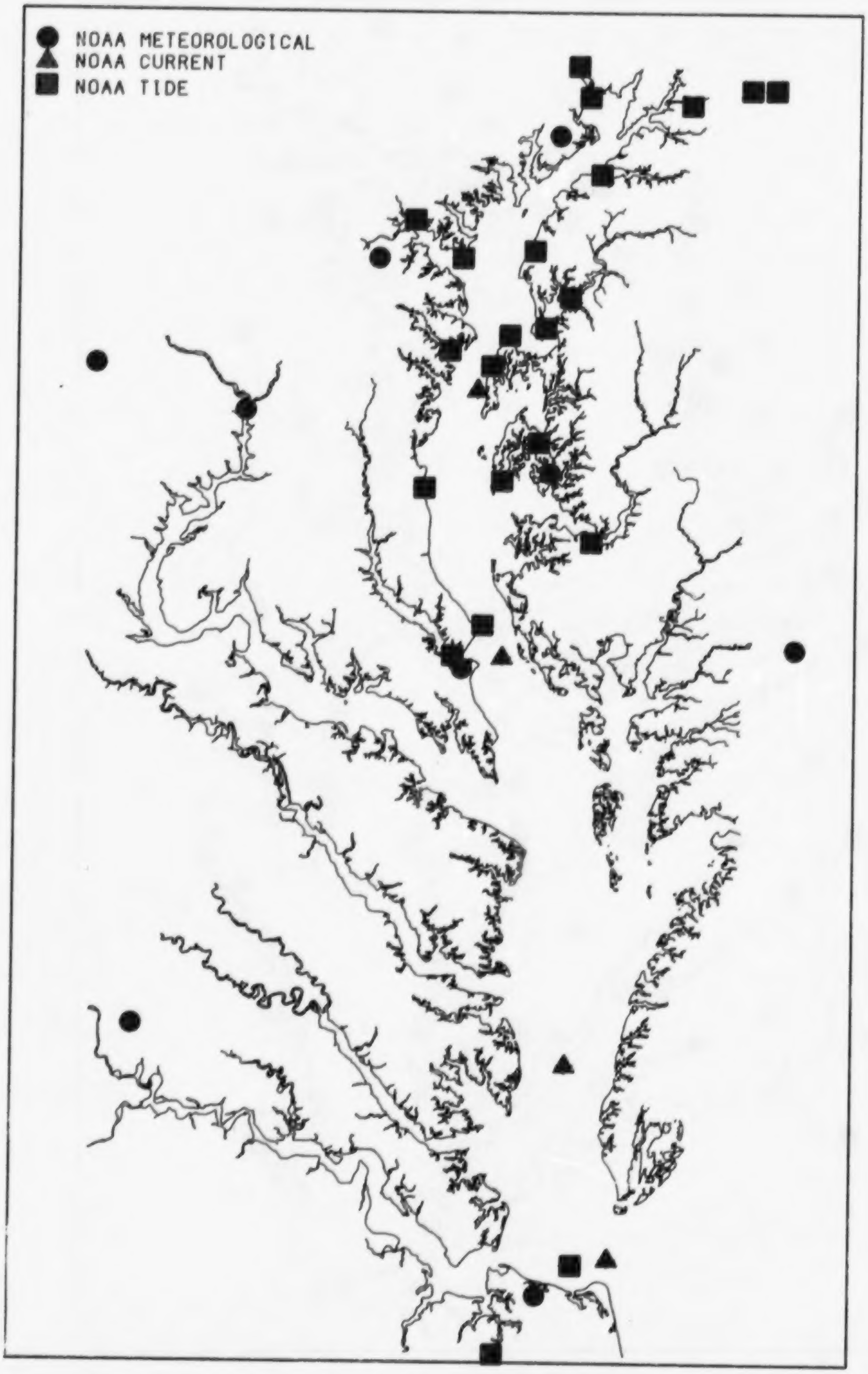

Figure 3e.1. NOAA meteorological, current, and tide monitoring stations.

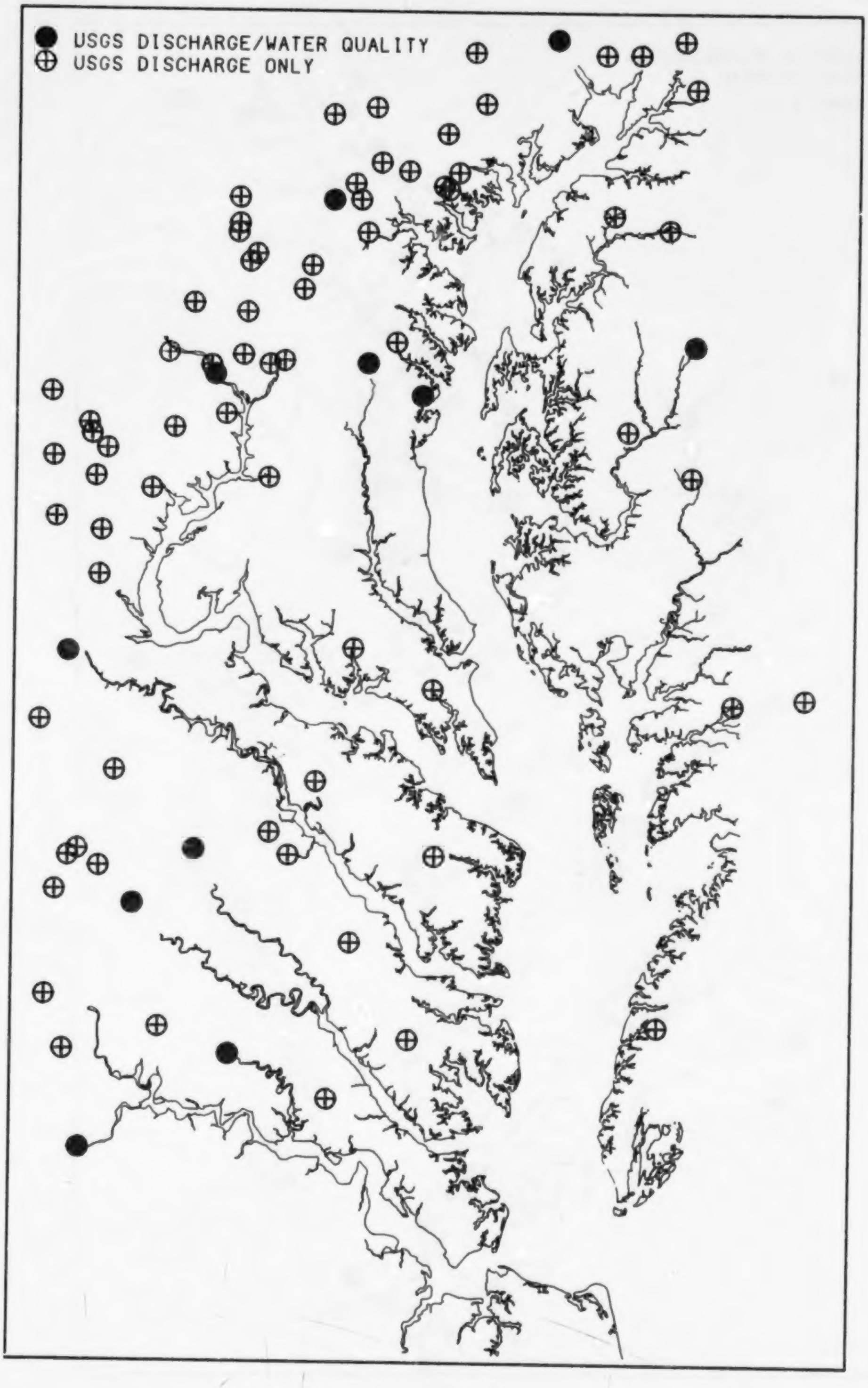

Figure 3e.2. USGS discharge and water quality monitoring stations.

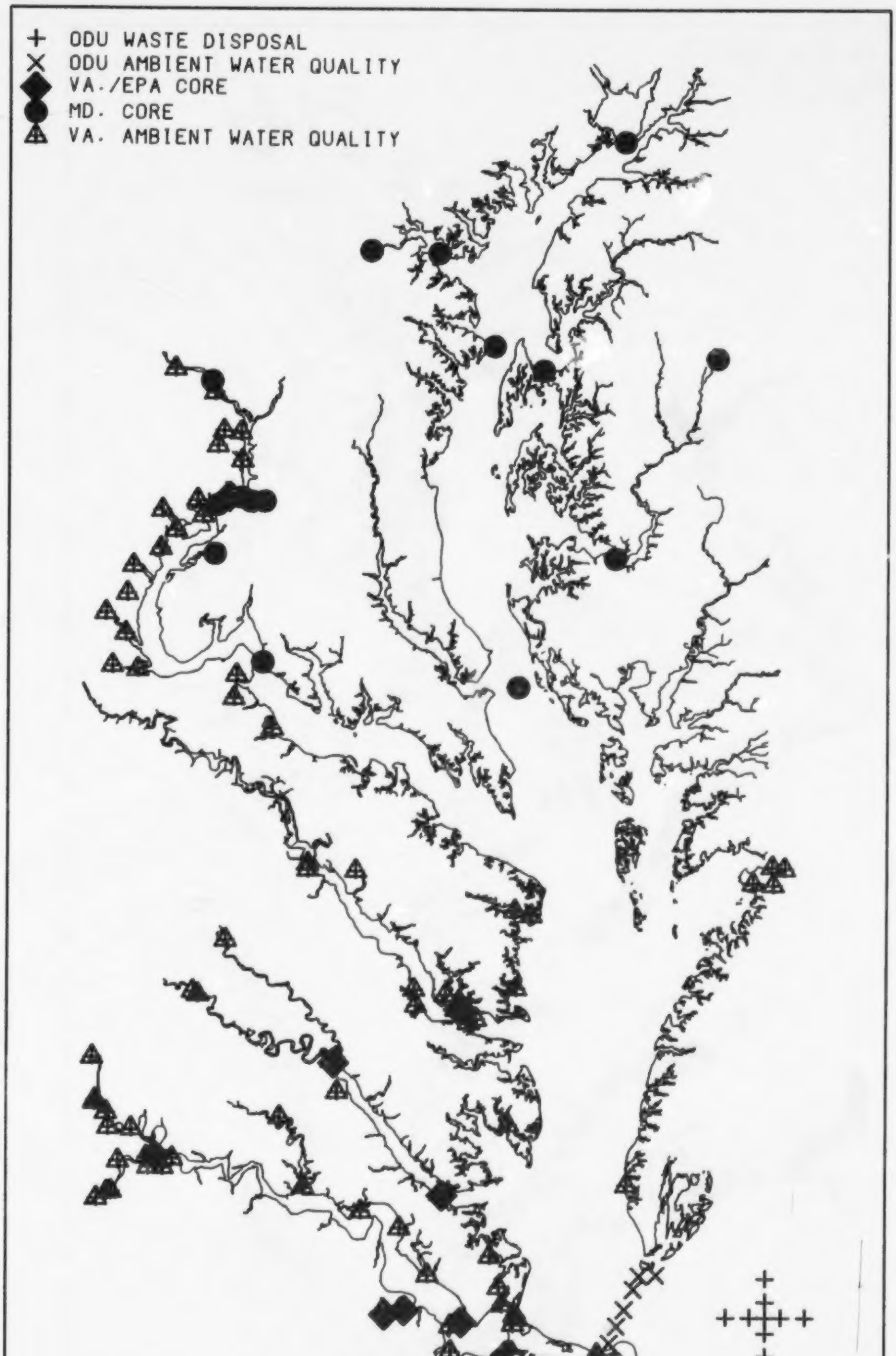

Figure 3e.3. Water quality monitoring stations sampled by the State of Maryland, the State of Virginia and Old Dominion University.

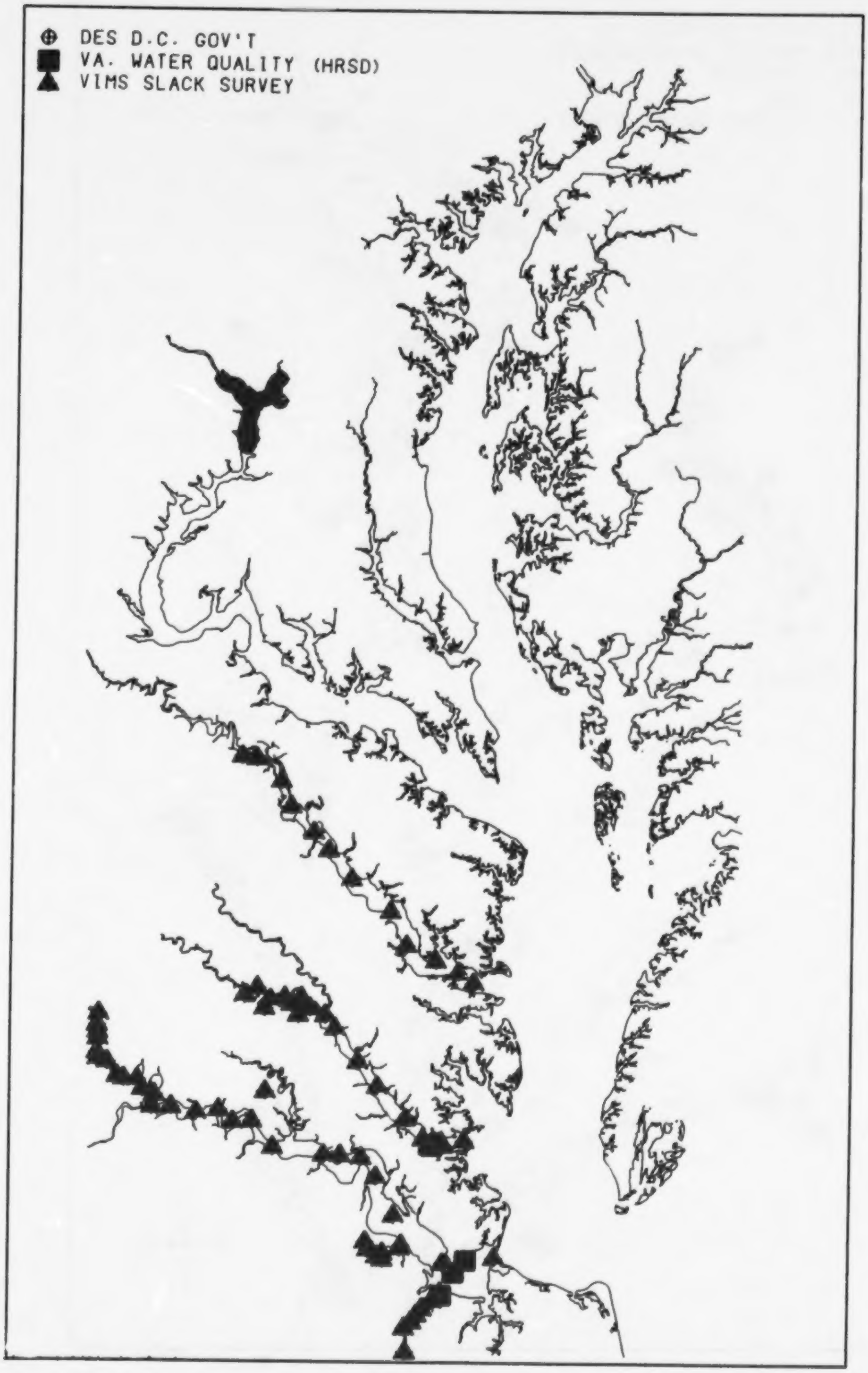

Figure 3e.4. Water quality monitoring stations sampled by the D.C. government, the State of Virginia and the Virginia Institute of Marine Science.

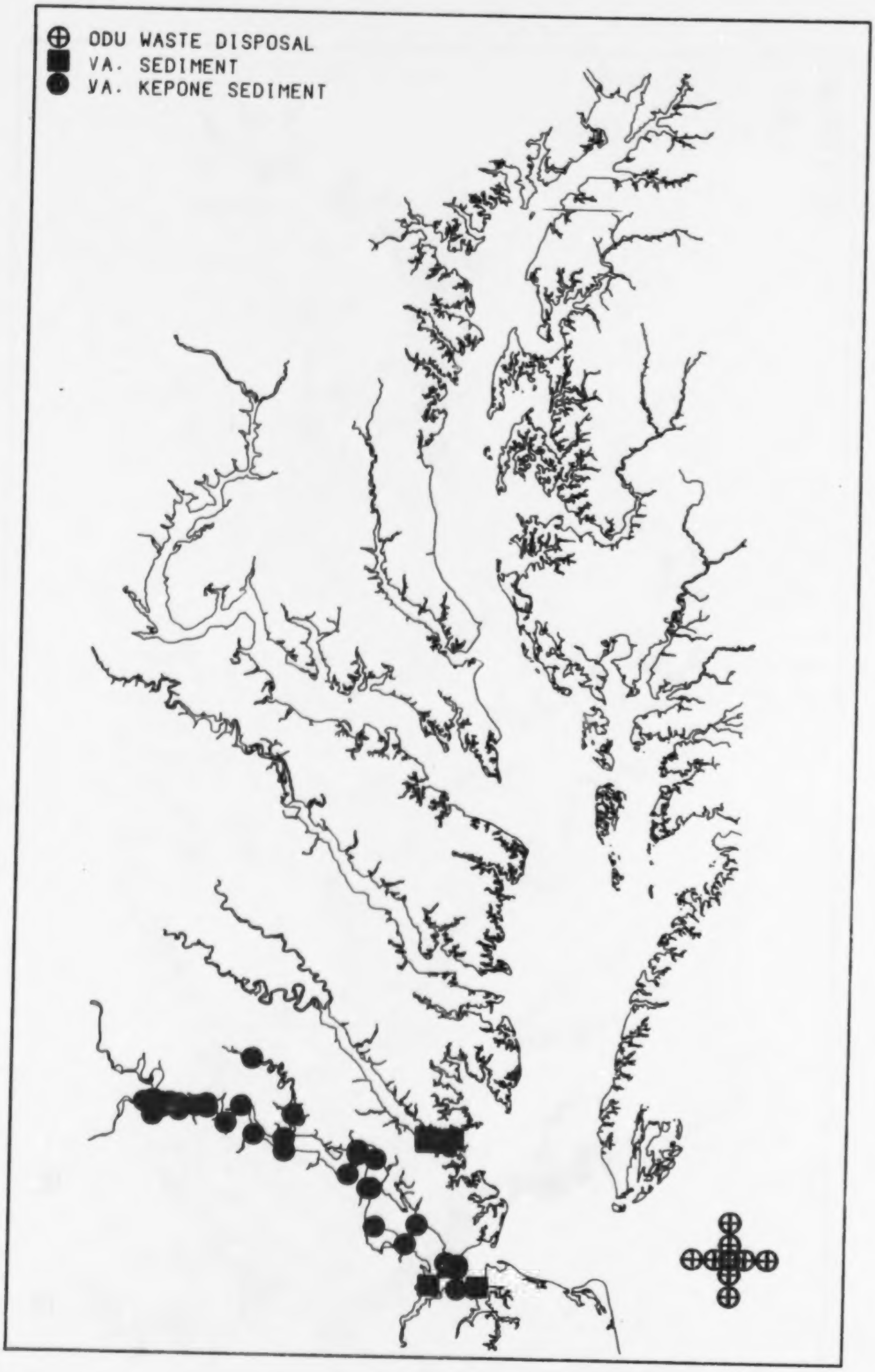

Figure 3e.5. Sediment monitoring stations sampled by Old Dominion University and the State of Virginia.

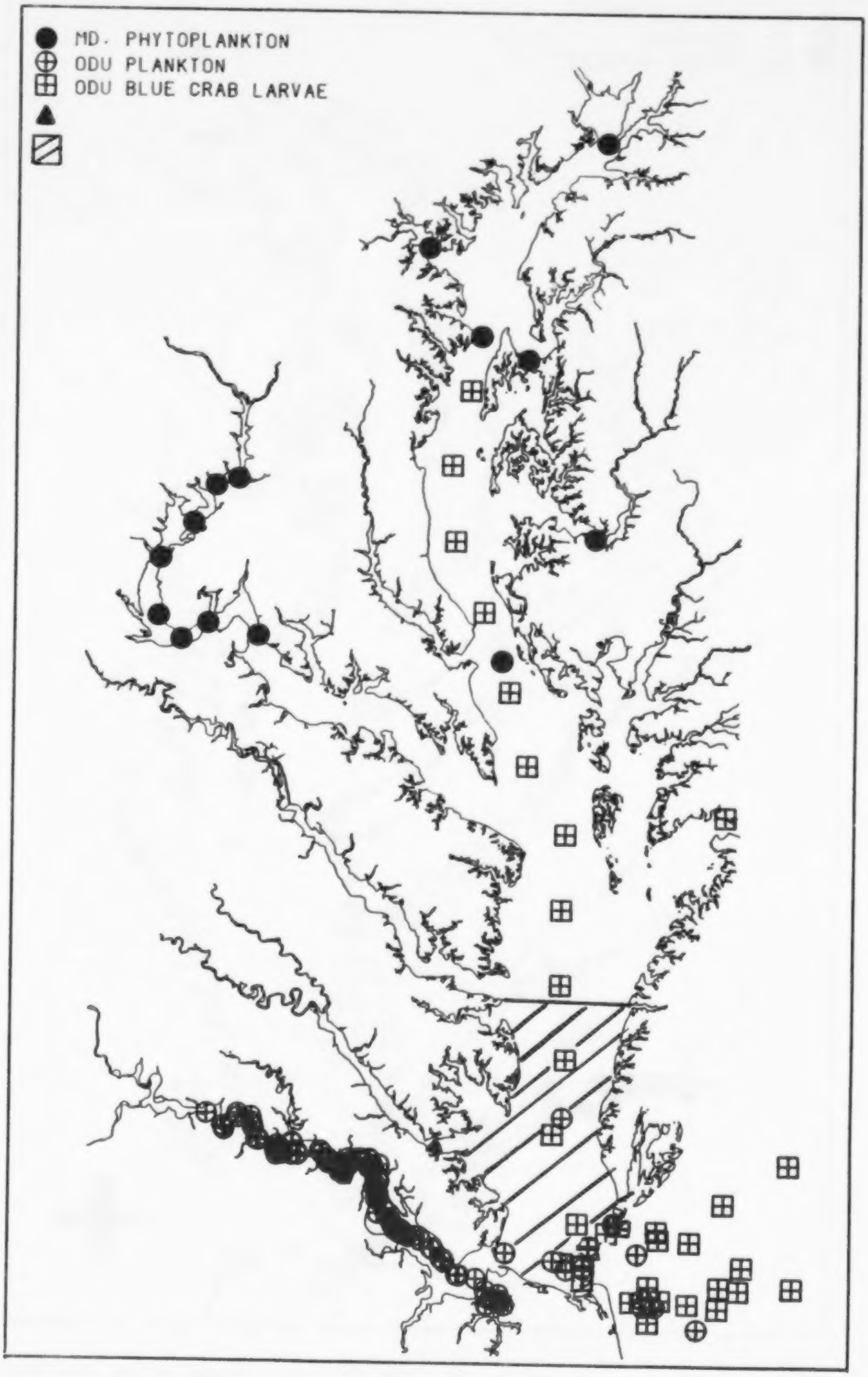

Figure 3e.6. Plankton monitoring stations sampled by the State of Maryland, Old Dominion University and the Virginia Institute of Marine Science.

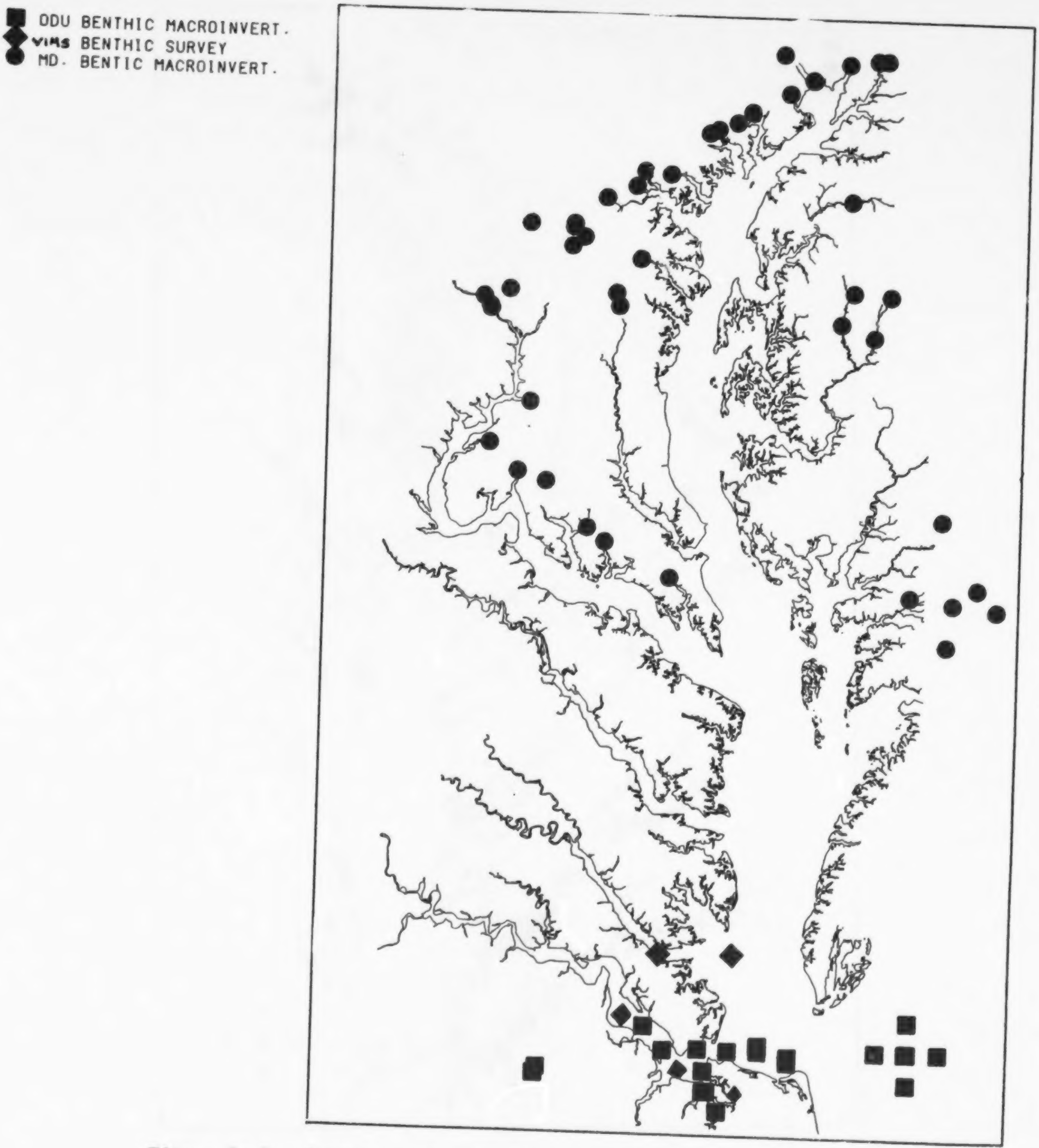

Figure 3e.7. Benthic monitoring stations sampled by Old Dominion University, the Virginia Institute of Marine Science, and the State of Maryland.

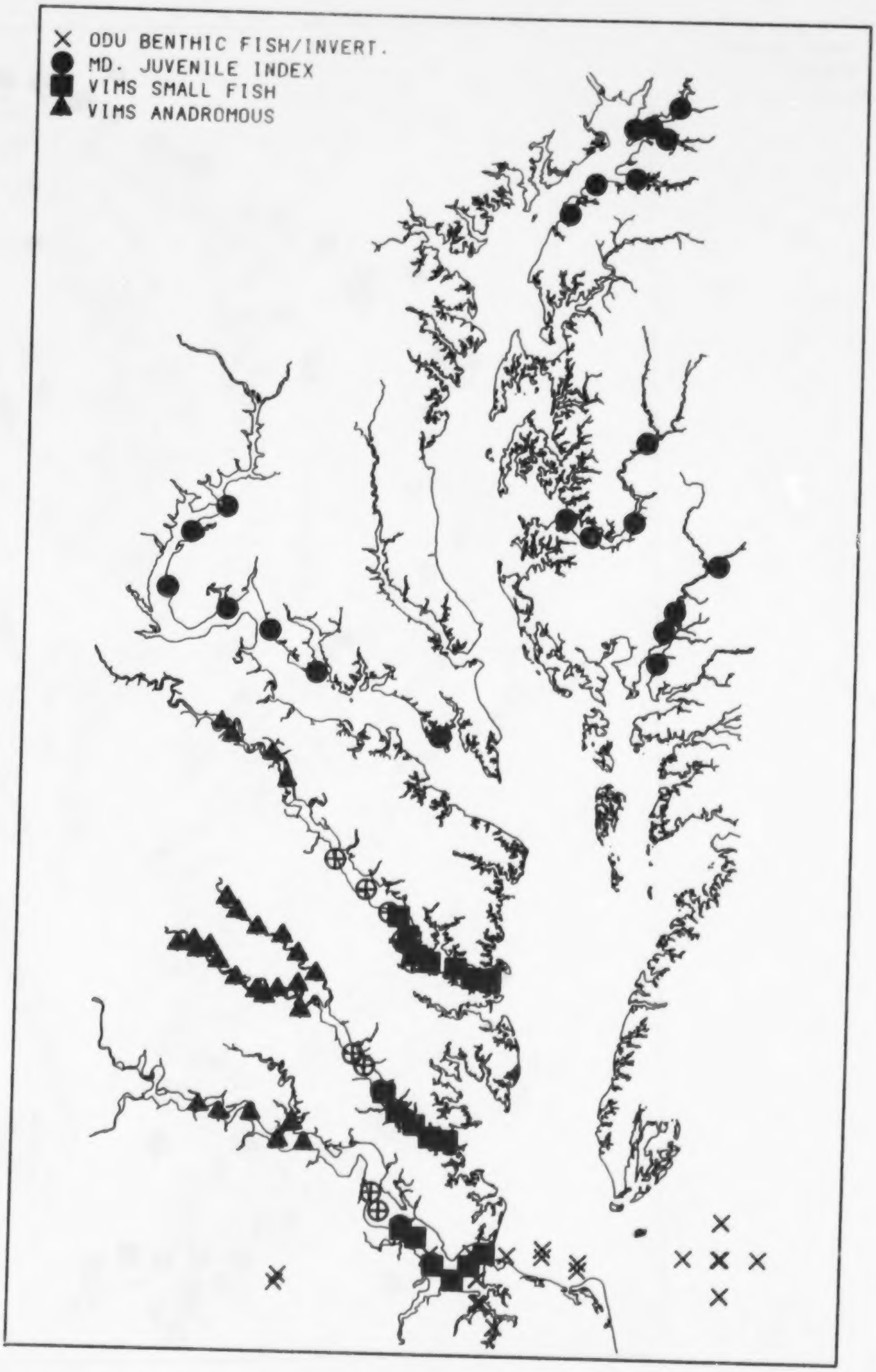

Figure 3e.8. Adult and juvenile fish monitoring stations sampled by Old Dominion University, the State of Maryland, and the Virginia Institute of Marine Science.

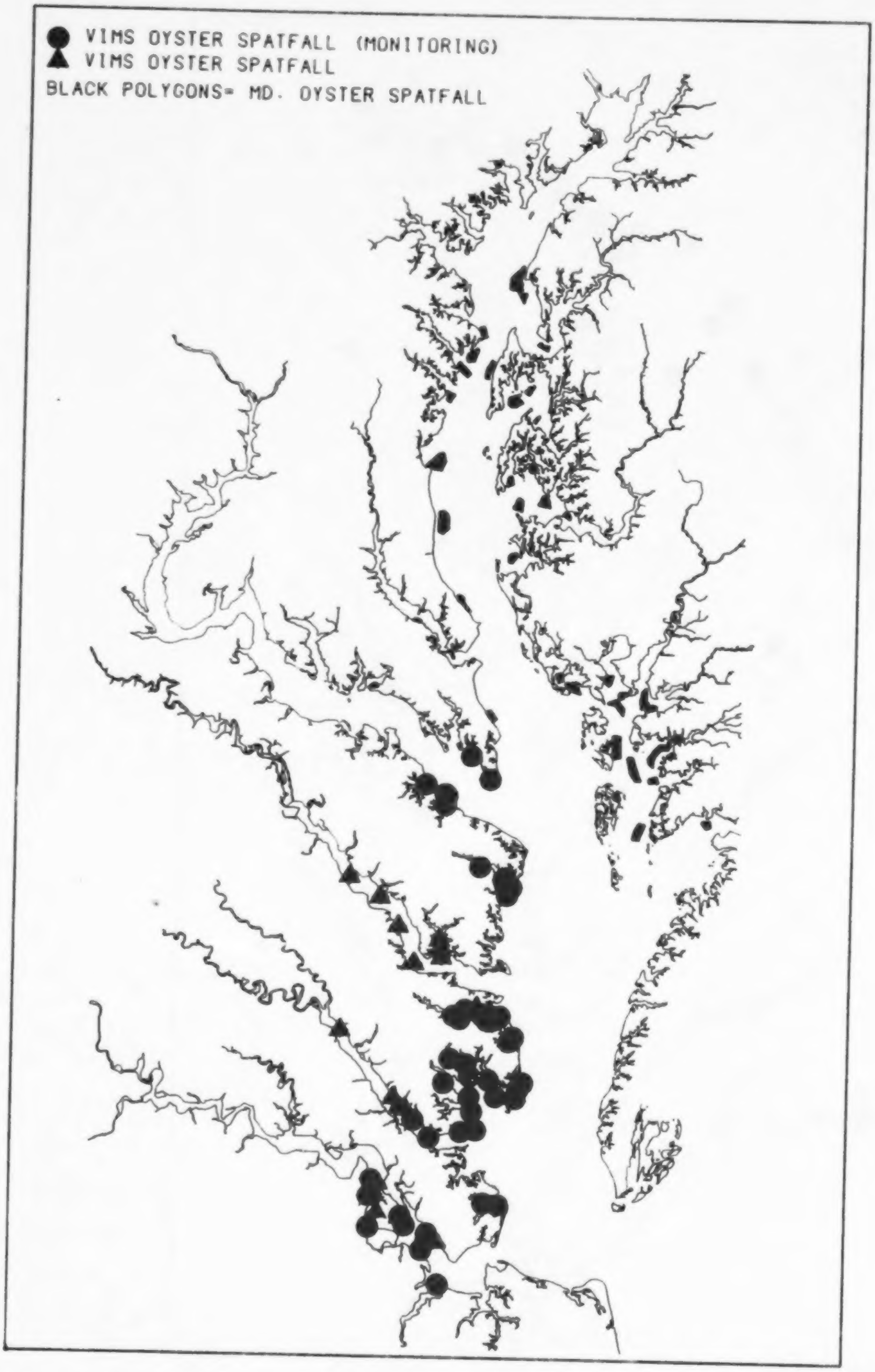
● VIMS OYSTER SPATFALL (MONITORING)
▲ VIMS OYSTER SPATFALL
BLACK POLYGONS= MD. OYSTER SPATFALL

Figure 3e.9. Oyster spatfall monitoring stations sampled by the Virginia Institute of Marine Science and the State of Maryland.

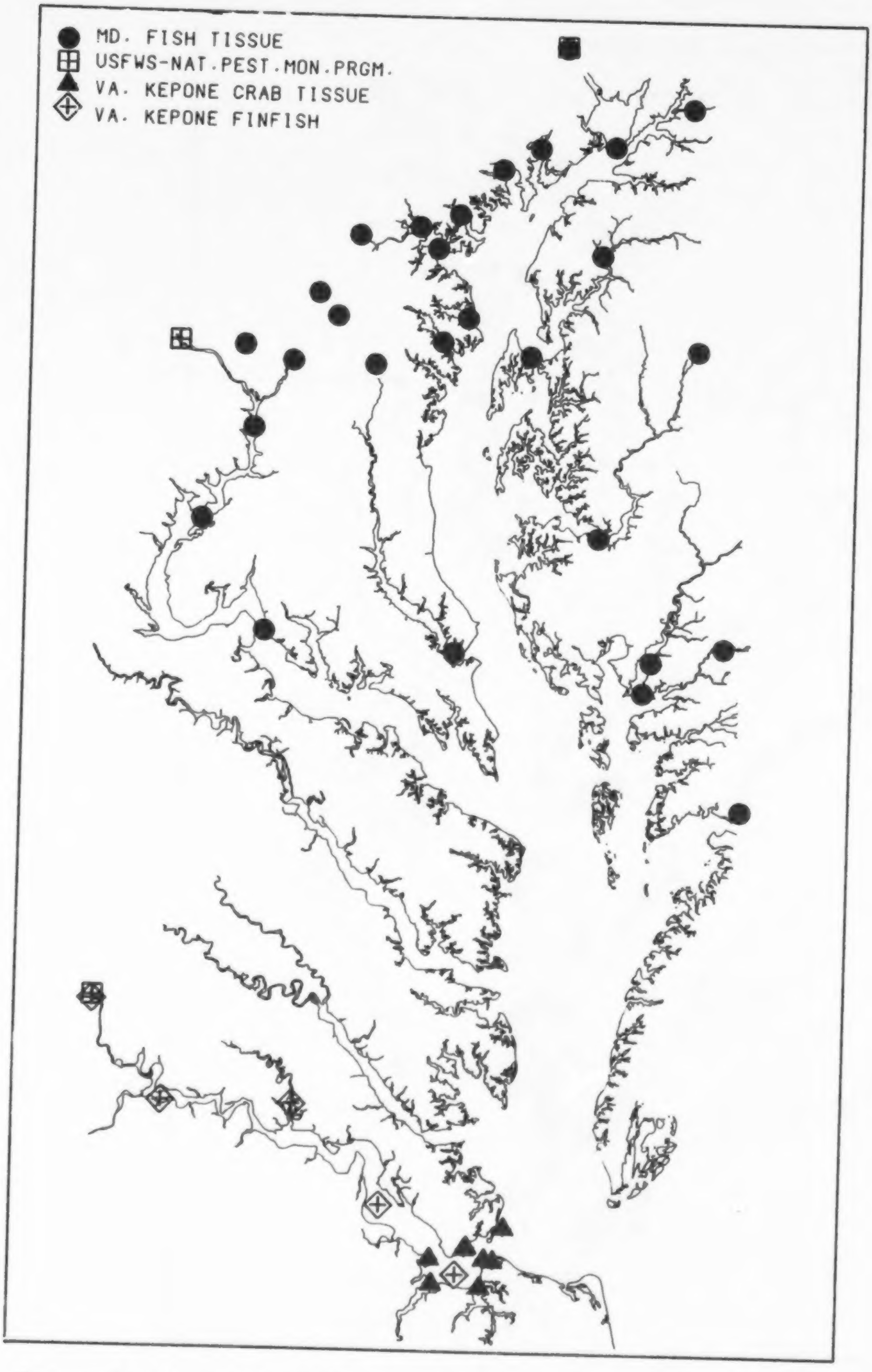

Figure 3e.10. Biological tissue monitoring stations sampled by the State of Maryland, US Fish and Wildlife Service, and the State of Virginia.

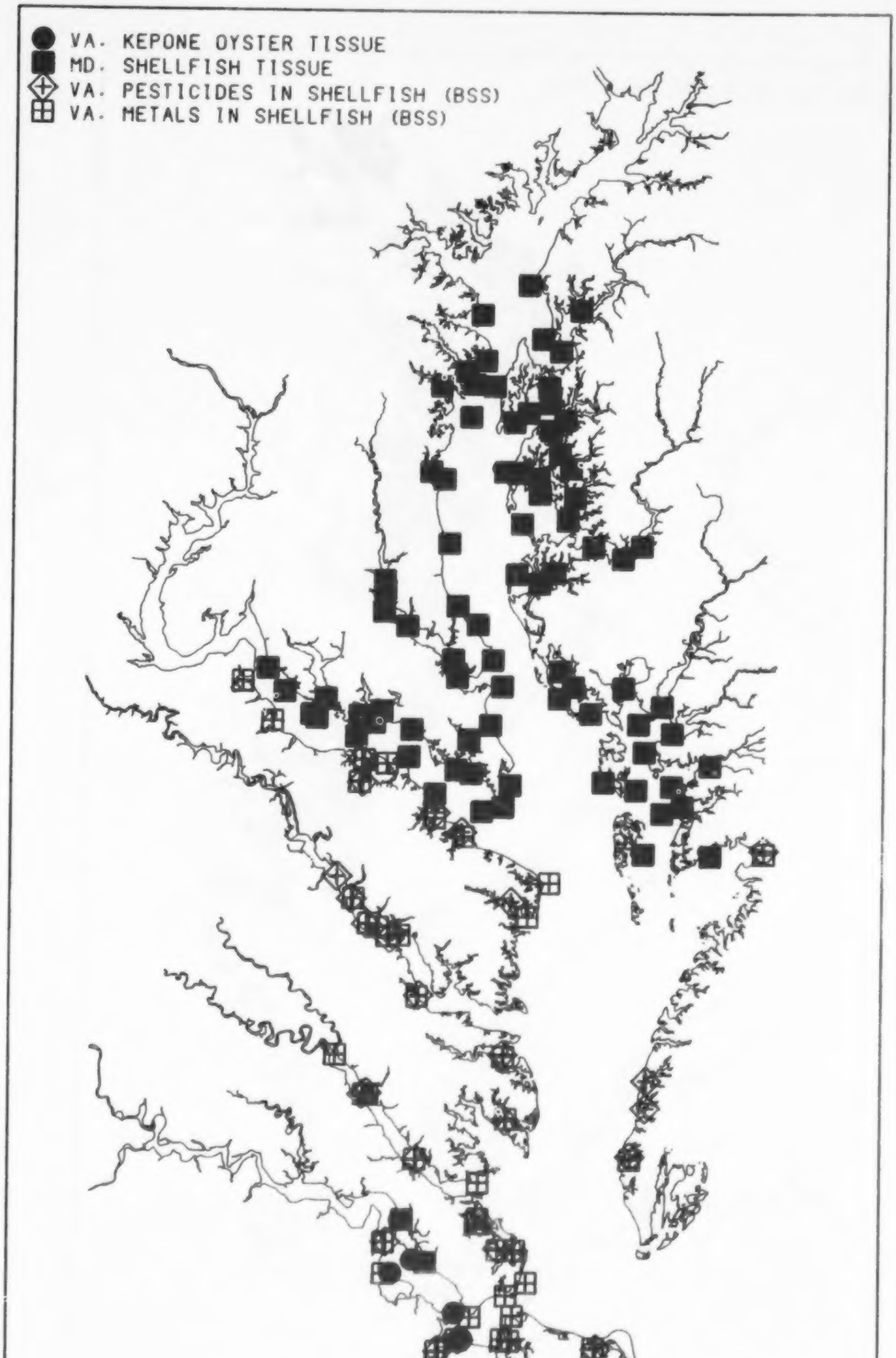
● VA. KEPONE OYSTER TISSUE
■ MD. SHELLFISH TISSUE
◈ VA. PESTICIDES IN SHELLFISH (BSS)
⊞ VA. METALS IN SHELLFISH (BSS)

Figure 3e.11. Shellfish tissue monitoring stations sampled by the State of Virginia and the State of Maryland.

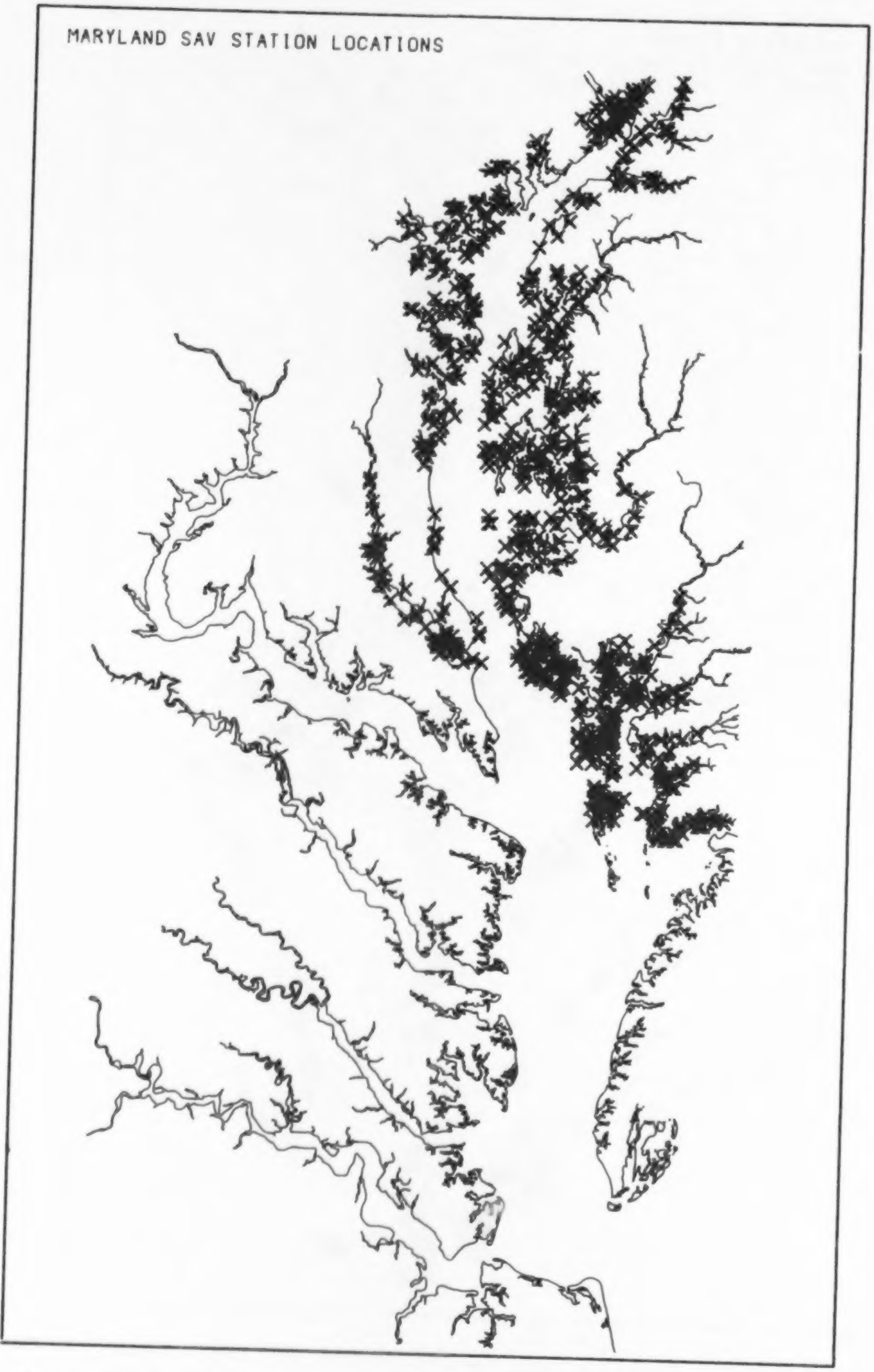

Figure 3e.12. Submerged aquatic vegetation monitoring stations sampled by the State of Maryland and the US Fish and Wildlife Service.

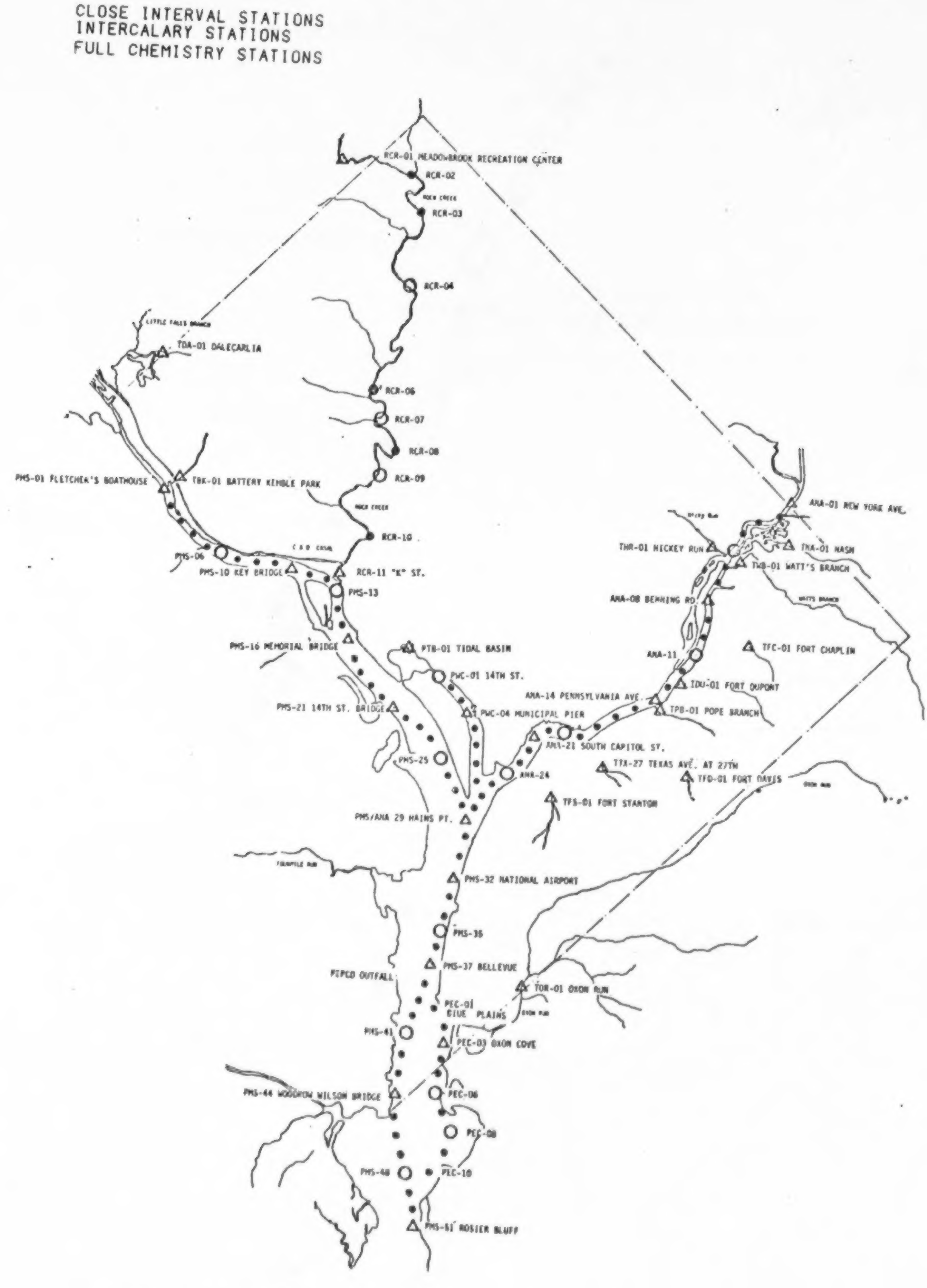

Figure 3e.13. Potomac river water quality and phytoplankton monitoring stations sampled by the District of Columbia government.

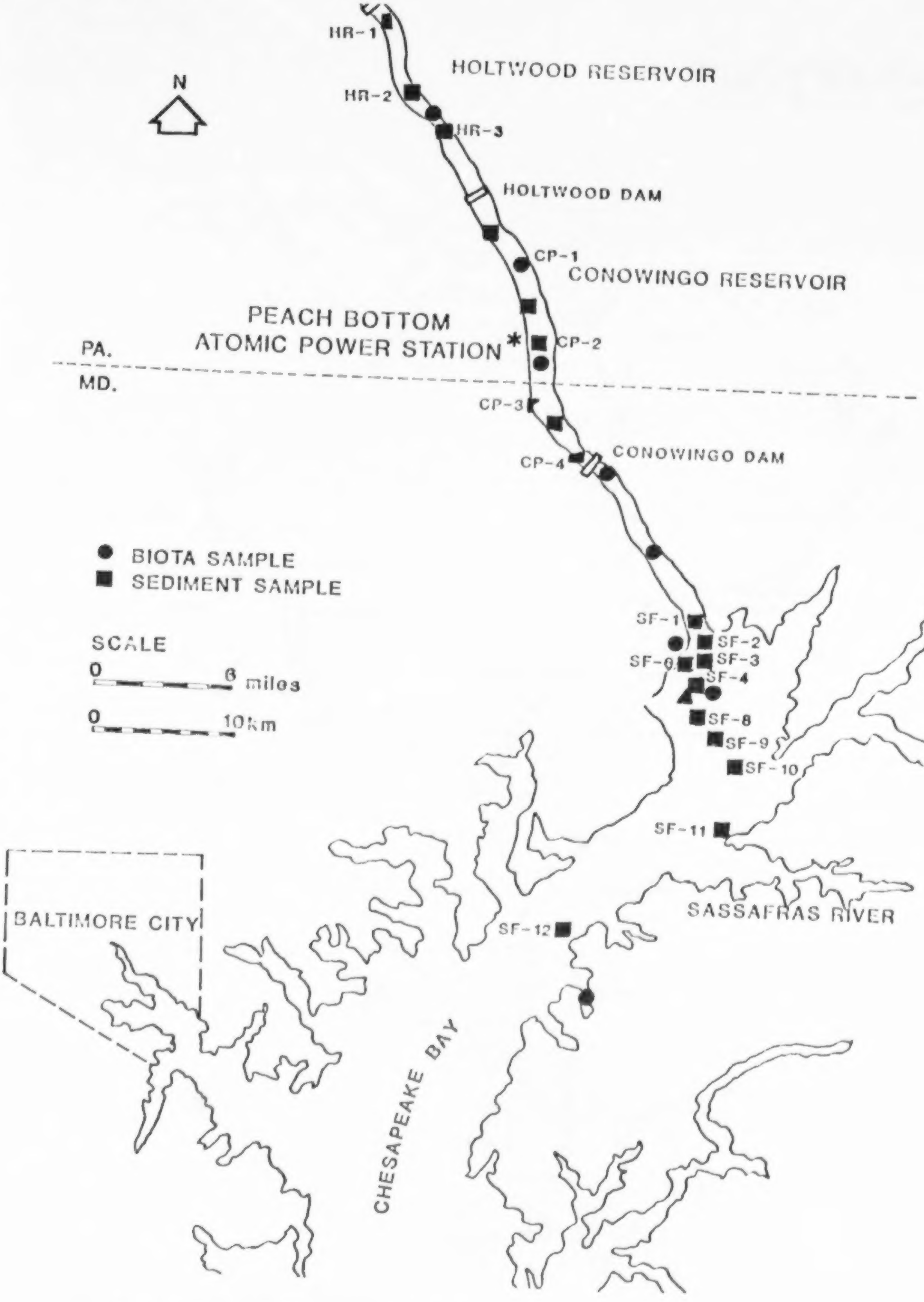

Figure 3e.14. Radiological survey conducted near the Peach Bottom nuclear power station.

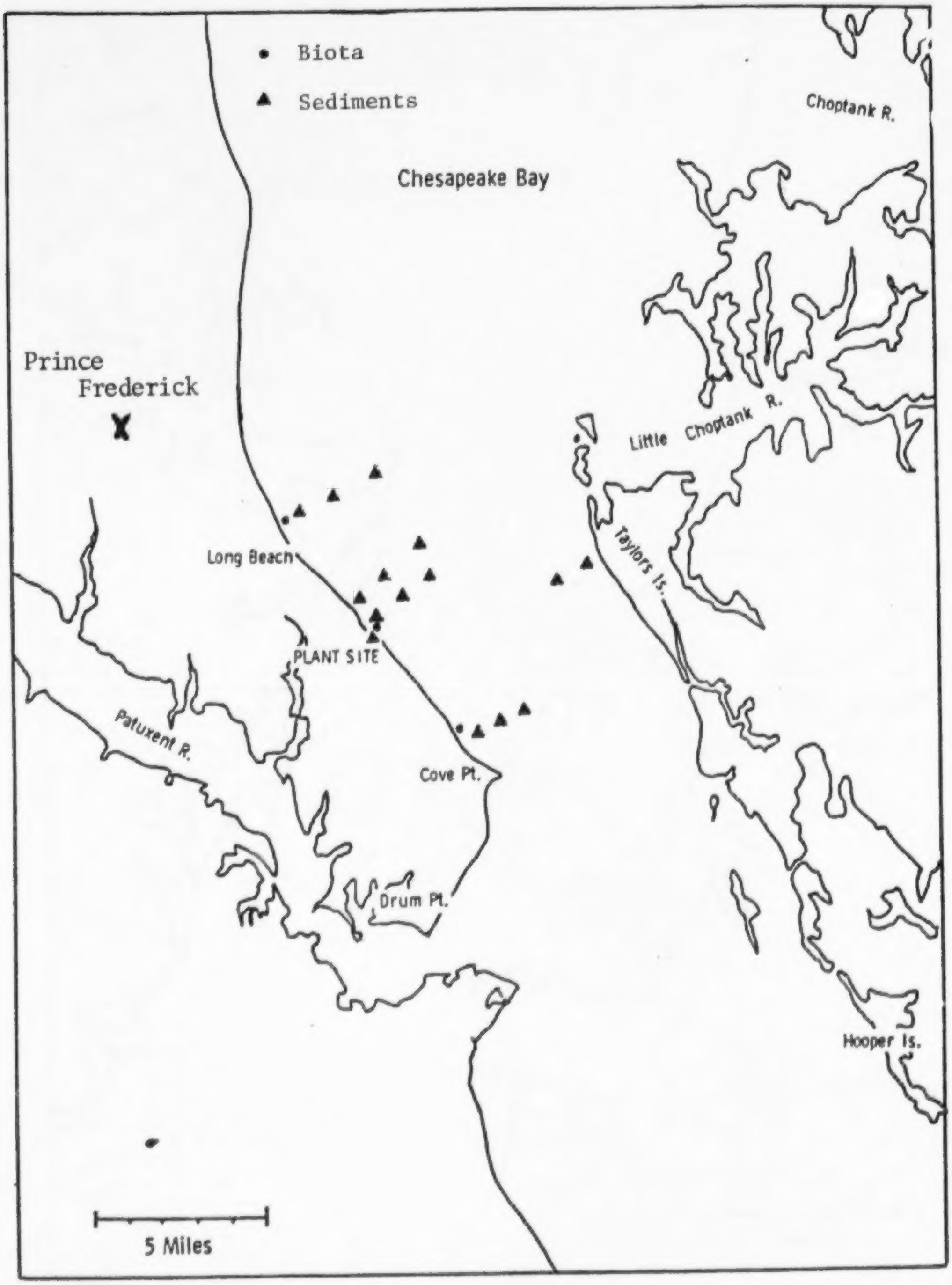

Figure 3e.15. Quarterly radiological survey conducted near the Calvert Cliffs nuclear power station.

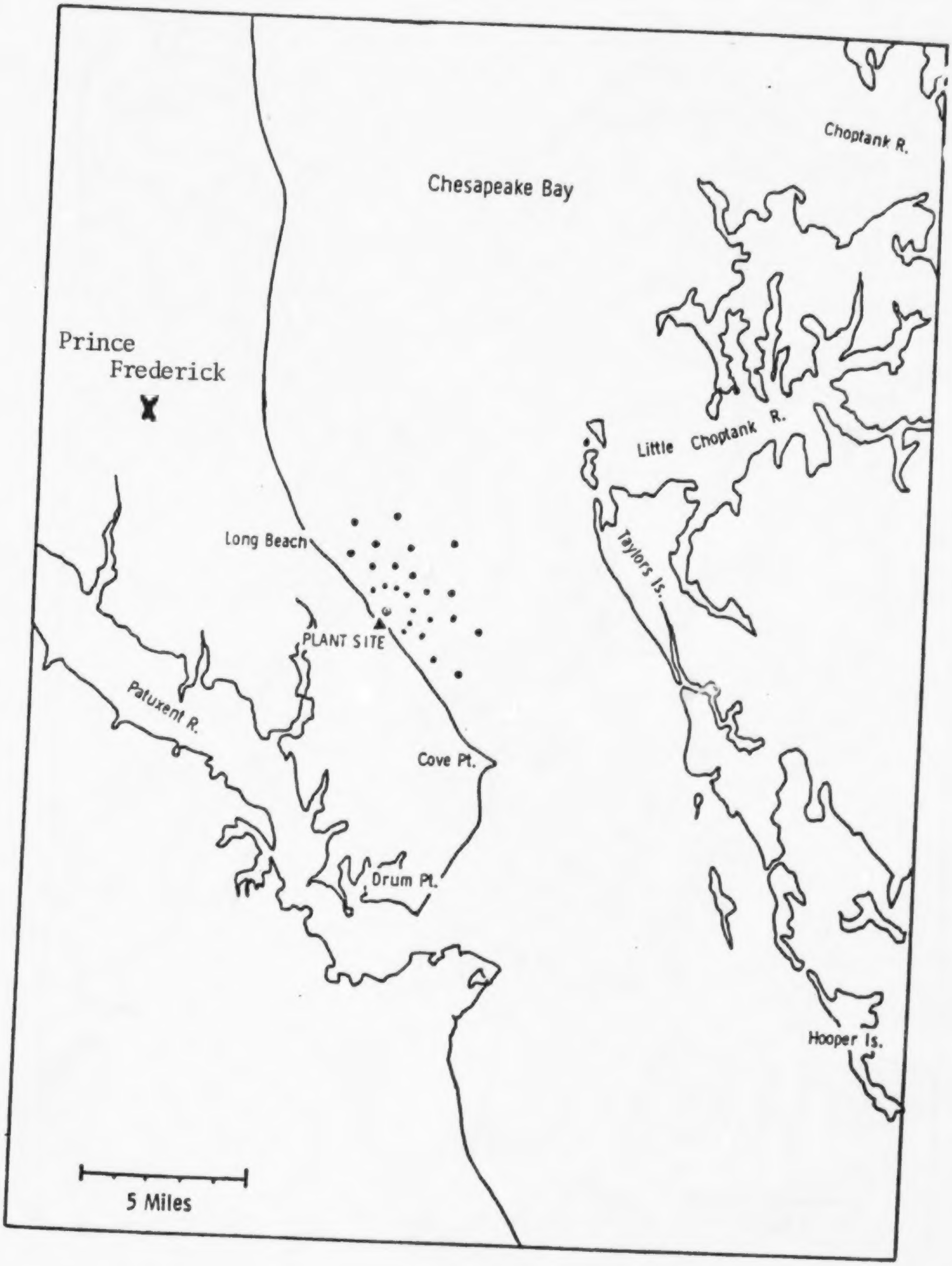

Figure 3e.16. Annual radiological survey conducted near the Calvert Cliffs nuclear power station.

# ATTACHMENT 4

## SECTION A

## CHESAPEAKE BY BIOLOGICAL RESOURCE MONITORING-DATA ACQUISITION AND ANALYSIS REQUIREMENTS AND RECOMMENDATIONS

During the process of evaluating the strengths and weaknesses of the present monitoring programs, several areas surfaced which could be further improved. The following section offers suggestions for improving our current monitoring efforts which should improve data analysis.

## LENGTH, INTENSITY, AND SCOPE OF SAMPLING

Preliminary findings from the CBP analysis of fisheries landings, juvenile finfish surveys, and oyster spat set surveys, as well as the scientific literature, indicate that climatically regulated natural cycles of abundance and decline in fisheries species may be on the order of twenty years in length (Cushing 1975). In addition, annual and spatial variation in abundance of a species may be substantial due to local and relatively short-term hydrographic and climatic effects. Therefore, to separate climatic from anthropogenic effects, biological monitoring programs must:

A. be designed to be statistically comparable and compatible with water quality, hydrographic, and climatic variable data collection efforts. At the very least this requires congruent sampling, data collection, and data analysis programs.

B. be conducted using essentially the same (standardized) techniques by competent technicians for very long periods of time (minimum of 20 years). The best local example of such a survey is Maryland Department of Natural Resources's survey of juvenile finfish. The principal deficiencies of this example are that water quality studies are not conducted congruently as suggested in "A" above. The survey should be expanded to other Bay tributaries especially to provide coverage in Virginia waters for better spatial discrimination of species trends. In addition, the survey should be tested for its effectiveness as an index of striped bass and other species abundance.

C. have experimental designs where sampling intensity and frequency are statistically determined by the natural variability of the data so that the data may be subjected to a sufficiently powerful statistical treatment to allow for the separation of natural and anthropogenic effects. Much of the CBP data base is not sufficiently synoptic or intense to allow for powerful statistical treatment.

(See specific recommendations on biological monitoring in next section).

## NEED FOR TRUE ABUNDANCE MEASUREMENTS

In addition to juvenile finfish and oyster spat set surveys, the only long-term biological data available to the CBP for comparison to water quality trends are fisheries landings data. However, as Rothschild, Richkus, and Ulanowicz have pointed out, fisheries landing statistics, as they were historically collected, did not include a measure of fishing effort (neither commercial nor recreational). Therefore, fisheries landings formerly bore little or no resemblance to fisheries species abundance in the field. What is needed at the very least would be monthly commercial and recreational effort statistics (now being collected by the Maryland Department of Natural Resources) for the species of interest and at best would be scientifically rigorous sampling programs designed to provide a field measure of abundance for several different life stages of key species.

## NEED TO UNDERSTAND BIOLOGICAL COMMUNITY STRUCTURE AND INTERACTIONS

The CBP analysis of fisheries trends versus water quality has stimulated an hypothesis concerning hydrographic "pumping" of the marine and coastal community of species into the Bay where they may compete with or prey on the equivalent freshwater/brackish water community. Although there is some evidence in the scientific literature to support this idea, in actuality little firm data are available on interactions of various species in Chesapeake Bay, even though such interactions may be the principal forcing functions in the expression of fishery trends.

## NEED TO DEVELOP BIOASSAY PROCEDURES THAT ALLOW INTERPRETATION OF LABORATORY DERIVED RESULTS TO FIELD CONDITIONS

Sindermann (1980) describes in some detail the difficulty of isolating and quantifying pollution effects on resource species--as distinct from effects of natural environmental variations. He states that the fact "that chemical pollutants cause stress and death in individual marine animals can be easily demonstrated, and has been repeatedly. Descriptions of lethal and sublethal effects of heavy metals, petroleum compounds and halogenated hydrocarbons abound in the experimental literature. That stress from chemical pollutants can have significant quantifiable effects on resource species abundance (apart from localized effects in severely contaminated coastal and estuarine zones) is much more difficult to demonstrate, and has not been documented satisfactorily" (Sindermann 1980).

This view is supported by Cole's (1975) inability to identify effects of pollution on North Sea fish and shellfish stocks and by Wise (1974), who reviewed on a species-by-species basis the catches of major estuarine dependent Atlantic fisheries. Wise's (1974) conclusion was that "the evidence from catch records of a substantial number of exploited estuarine species in United States waters indicates that pollution and damage to estuaries have not yet shown any measurable overall effect on the part of the marine resources which might be expected to show the first effects."

A recent review of ecological stress in the New York Bight (Mayer 1982) supports the previously described viewpoint that even in an area as heavily impacted as the New York Bight it is nearly impossible to demonstrate pollution-induced changes in the growth and distribution of populations of plankton (Lee et al. 1982), invertebrate communities (Wolfe et al. 1982), and fishes (Sindermann et al. 1982). On the other hand, Carriker et al. (1982) indicate that temporal and spatial trends exist in the distribution and abundance of some benthic organisms in lower Raritan Bay and the New York Bight apex as a result of pollution.

Therefore, some effort should be made to devise a standardized bioassay procedure that might make use of established aquaculture techniques and key ecological, commercial, and recreational species such as the American oyster, striped bass, blue crab, etc. to provide, at the very least, a qualitative comparison of the gross toxicity of water from various locations around the Bay and, at best, a relative measure of the toxicities of the individual contaminants within each water sample.

## SECTION B

## SPECIFIC RECOMMENDATIONS ON BIOLOGICAL MONITORING OF CHESAPEAKE BAY

### Juvenile Finfish Survey

Station location and sampling scheme:

1. Stations currently occupied in the head of the Bay, and the Potomac, Choptank, and Nanticoke Rivers by the Maryland Department of Natural Resources (MD DNR) should be maintained to preserve the historical integrity of the survey (Attachment 3, Section E).

2. Equivalent numbers of stations (4 to 7) per estuary should be specified for an indentical juvenile finfish survey to be conducted in the Rappahannock, York, and James Rivers in Virginia.

3. Concurrent water quality sampling should be conducted.

4. Late summer and early fall is probably the best time to obtain maximum numbers of species and young-of-the-year fish for spring and early-summer spawners (primarily the anadromous species). Therefore, the current seasonal schedule followed by MD DNR appears appropriate.

5. Gear and seining techniques should be equivalent to the recent history of the MD DNR for shore stations. However, it is desirable to have deep-water (channel) trawl stations using net and mesh size and towing areas roughly equivalent to shore seines for comparison to shore collections to properly sample deeper water benthic types such as the sciaenids. The trawling efforts should be patterned after the VIMS trawl surveys to provide historical consistency and consist of 10 to 15 minute length tows (Guillory et al. 1980).

6. In addition to identifying and counting age 0 (young-of-the-year) fish, it is also highly desirable to identify and count age 1 (one year old) fish where known length frequencies allow one to identify age 1 fish. This would assist in determining mortality rates during the first year.

7. The CBP is currently conducting an analysis of the variability of the MD DNR juvenile finfish survey data using striped bass data, assuming 5 stations per estuary and collections during July, August, and

September, to estimate the number of replicates per station per month that would be necessary to detect a statistically significant change in the mean number of striped bass collected from year to year in a given estuary (basin). Sampling frequency analyses in other studies in similar estuaries (Campbell 1975) show that to collect in excess of 85 percent of the species available (51 of 58) it is necessary to collect about 480 samples per estuary evenly spaced throughout the year. Presuming that a three month quarter of mid-July through mid-October would suffice, 120 samples per estuary per season would be required. Presuming five shore stations and five channel stations per estuary in the Chesapeake or its tributaries, then each station should be replicated four times per month for the three month season. In a similar shore zone fish survey, Derrickson and Price (1973) calculated that each pass of the seine has a capture efficiency of slightly more than 50 percent of the available fish in an area where escape by the fish was difficult. Theoretically then four seine or trawl passes should provide over 90 percent of the fish available when escape is not possible. Obviously the assumption is not true, but it should be realistic for young-of-the-year fish which should be less able to avoid capture.

Doubleday (1980) indicates that more than 100 sets (samples) at a given location are necessary to reduce margins of statistical error to below ± 50 percent. Other researchers (Guillory et al. 1980) have shown that several hundred replicate trawl samples are necessary to detect change at a 95 percent confidence level using ten-minute tows. However, they support the idea that four replicates as suggested in this recommendation will at least provide evidence of major trends but will not be prohibitively expensive or demanding of human and financial resources.

Oyster Spat Survey

1. Key stations currently occupied in both Maryland (Meritt 1977, Davis et al. 1981) and Virginia (Haven et al. 1978) should be maintained using equivalent sampling gear and strategies to preserve the historical integrity of the survey.

2. The September - October sampling period should be maintained because it is biologically reasonable and to preserve the historical integrity of the survey.

3. In view of growing hypoxic conditions in the Bay in the summer period, additional stations should be added, if necessary, to detect the detrimental effects of the encroachment of low oxygen water.

4. An analysis of the variability of the spat set data currently collected is being conducted with the intent of predicting the number of key bar stations and replicates per station per year that would be necessary to detect a change in number of oyster spat collected from year to year in a given estuary (basin).

5. Water quality sampling and tissue analysis should be done at the key oyster bars.

## Submerged Aquatic Vegetation Survey

Submerged aquatic vegetation (SAV) baseline monitoring should also be done at a level II effort. The following is a suggested approach:

A. Aerial photography is recommended to be done annually for the estimation of year-to-year distribution and the extent of beds. Timing suggested is for the lower Bay in May or June, and the upper Bay in June.

B. For community composition and condition, ground truthing is necessary. It is also necessary to calibrate the density of beds observed with aerial photography. Ground-truthing station density should be greater in Maryland because of greater diversity of SAV community type.

Parameters suggested at ground truth stations include:

1) salinity;

2) temperature (water);

3) pH, in fresh water;

4) light penetration (Secchi depth);

5) weather (sea state, wind);

6) water depth at station;

7) stage of tide (or time of day to estimate tidal stage);

8) note general condition of station - vegetated, apparent condition of bed, non-vegetated;

9) density or biomass in a standard area;

10) relative abundance of various species present; and

11) take samples at selected sites for later examination for epiphytes, leaf-stem morphology, etc.

The current Maryland Department of Natural Resources summer vegetation survey does most of the above (Attachment 3, Figure 3e.12). For completeness, this type of ground truthing must be extended to the Potomac River and Virginia. For economic reasons, it may be necessary to reduce the number of SAV survey stations in Maryland. Attachment 8 gives specific analysis and recommendations regarding future SAV monitoring in the upper Bay. Some flexibility in ground truthing should be retained. It may be necessary to return during the season to stations which data analyses show are experiencing a lot of change. Ground truthing in Virginia and Maryland should be comparable in techniques and parameters measured. In Virginia, SAV should be looked at in other than polyhaline areas.

## Phytoplankton Survey

Because phytoplankton community composition and abundance is a good indicator of water quality, it is recommended that a regular program of phytoplankton monitoring (level II) be carried out monthly in the tidal-fresh areas where bluegreens can become a problem, and in the lower estuarine areas where dinoflagellates proliferate. This sampling should correspond with the water quality stations.

# ATTACHMENT 5
# VOLUNTEER MONITORING PROGRAM

Volunteer monitoring is a relatively new idea which has been instituted in a few areas around the country. These programs call for citizen volunteers to sample the waters near where they live for certain parameters and report their findings on a regular basis to an organizing agency. Citizens in Rhode Island have been monitoring their waters for the past five years and have produced a very valuable data set. It is felt by many that such a program around Chesapeake Bay could be very successful because Bay area citizens have always expressed their concern for, and their interest in, the health of the Bay.

For the purpose of trend assessment in the shallow reaches of Chesapeake Bay, the concept of a Citizen's Bay Watch could be an alternative to a highly structured and expensive institutional monitoring program. All of the considerations stated earlier would remain important, including selecting data appropriate for collection, assuring data quality, and maintaining the network over an extended time period. Properly established and managed, such a program could provide valuable insights into trends in the estuary at a very reasonable cost.

Initially, such a program would be established using a core network of interested citizens, trained in elementary data acquisition and observation. Preferably, the system would use citizens with access to the water by pier or small boat, and with a high probability of remaining at that site for several years.

Once established, the network would require input and feedback from the overseeing organization on a regular basis. Feedback could take the form of newsletters, seminars, etc., and would assure continued interest and a quality data base.

Selecting the parameters to be collected would require a careful analysis of the goals of the program and the methodologies available. Quantitative information on turbidity, dissolved oxygen, temperature, and pH could be easily collected and its accuracy ensured by a simple quality assurance program. Qualitative information such as grass cover, water appearance, bottom color, and the relative abundance of living resouces could also be collected. Models for acquiring this type of information already exist as demonstrated by the pond monitoring program in Rhode Island, and the Save our Streams citizens' stream survey in Maryland.

As the network matured, it could be expanded to other near-shore locations and eventually off-shore. Moving the monitoring program to deeper waters would require the recruitment of interested boaters. Due to the lack of a consistent sampling regime, it may prove difficult to demonstrate trends in water quality and biological resources. However, this kind of citizen participation would provide insight into transient environmental events which are difficult to document with a highly structured monitoring program. Again, feedback to the participants and a quality assurance program would have to be designed and incorporated.

A second opportunity exists for citizen participation in labor intensive monitoring programs. For example, the State of Maryland's annual anadromous fish spawning stock survey could be made more effective by using university and community college students to aid the permanent staff. Establishing this program would require that a central clearing-house be established and that the monitoring and research agencies be made aware of the resource. The logical site for such a clearing-house would be at one of the several educational institutions with an active environmental science program in the affected states (i.e., University of Maryland, VIMS, AACC, ODU).

More specific plans for volunteer monitoring will be established after this document has been published and should be included in another document at a later date.

# ATTACHMENT 6
# BASELINE MONITORING

This attachment presents a table of the baseline monitoring stations as discussed in Section 3. The station ID codes are based on the CBP segmentation scheme (Figure 4). The first letter of the code refers to the state (Maryland or Virginia) in which the station is located. The next three or four characters represent the segment ID and the last character is the number of the station within that segment. Station numbers that are part of a transect will have either an E or a W at the end which stands for east or west. For example, MCB4.3W is a Maryland station located in segment CB-4 (main Bay) and it is the third station in segment CB-4. It is a transect station on the west side of station MCB4.3. Figure 6.1 shows the approximate location for each of the stations.

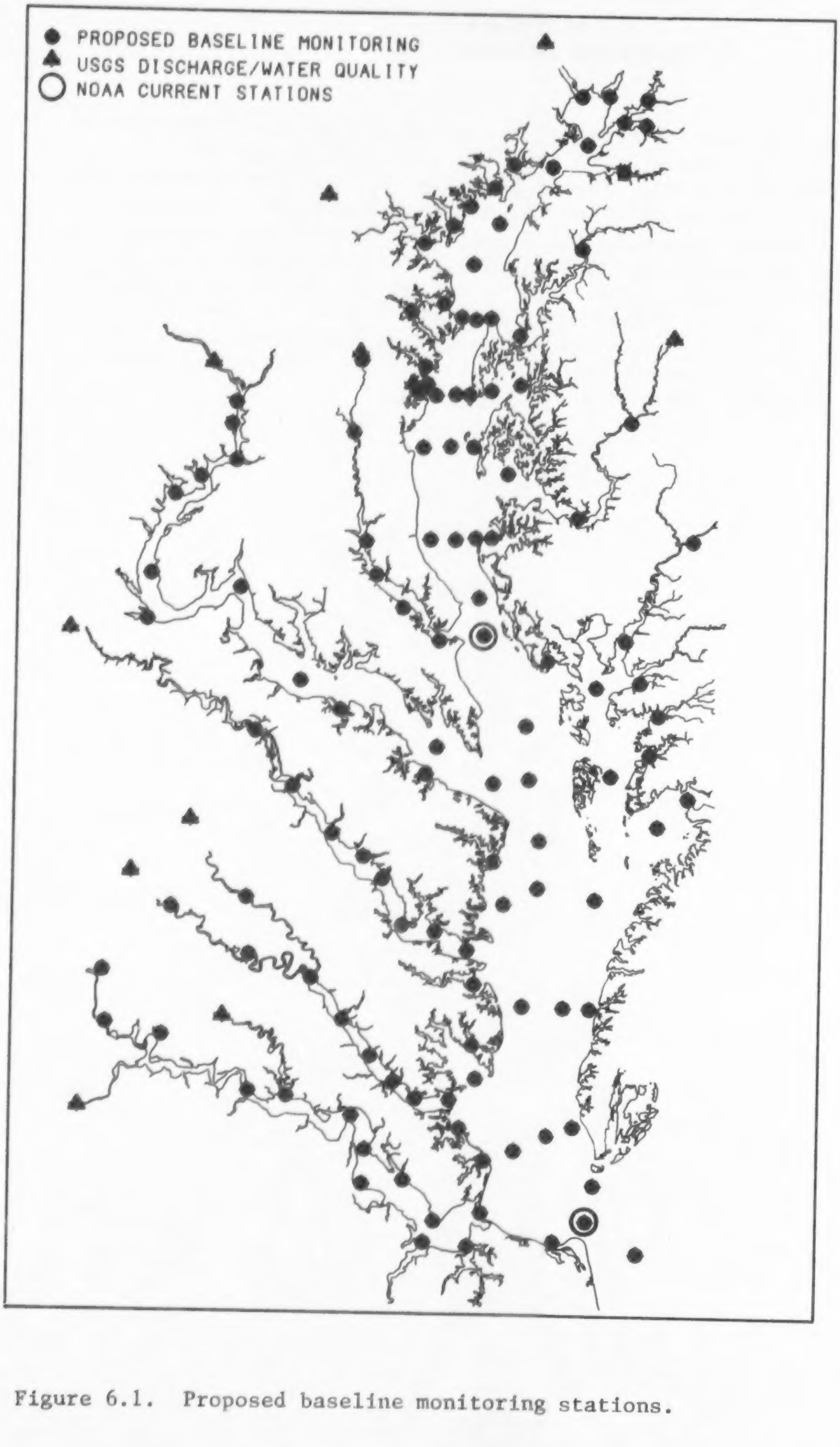
● PROPOSED BASELINE MONITORING
▲ USGS DISCHARGE/WATER QUALITY
○ NOAA CURRENT STATIONS

Figure 6.1. Proposed baseline monitoring stations.

TABLE 6.1. WATER QUALITY BASELINE MONITORING

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| Maryland - Western Shore Tributaries | | | |
| MWT1.1 | 19 | monthly | surface and bottom<br>S/B |
| MWT2.1 | 19 | monthly | S/B |
| MWT3.1 | 19 | monthly | S/B |
| MWT4.1 | 19 | monthly | S/B |
| MWT5.1 | 19 | monthly | 4 |
| MWT6.1 | 19 | monthly | S/B |
| MWT7.1 | 19 | monthly | S/B |
| MWT8.1 | 19 | monthly | S/B |
| MWT8.2 | 19 | monthly | S/B |
| MWT8.3 | 19 | monthly | S/B |
| Patuxent River | | | |
| MTF1.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MTF1.2 | 19 | monthly | S/B |
| MRET1.1 | 19 | monthly | S/B |
| MLE1.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MLE1.2 | 19 | monthly | 4 |
| MLE1.3 | 19 | monthly | 4 |
| Potomac River | | | |
| MTF2.1 | 19 | monthly | S/B |
| MRET2.1 | 19 | monthly | 4 |
| MRET2.2 | 19 | monthly | 4 |
| MLE2.1 | 19 | monthly | 4 |
| MLE2.2 | 19 | monthly | 4 |
| MLE2.3 | 19 | monthly | 4 |
| VTF2.1 | 19 | monthly | S/B |
| VTF2.2 | 19 | monthly | S/B |
| VTF2.3 | 19 | monthly | S/B |
| VTF2.4 | 19 | monthly | S/B |
| VRET2.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VLE2.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VLE2.2 | 19 | bi-monthly, Mar-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | S/B |

bi-monthly = twice a month

(continued)

TABLE 6.1 (Continued)

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| Eastern Shore Tributaries and Embayments | | | |
| MET1.1 | 19 | monthly | S/B |
| MET2.1 | 19 | monthly | S/B |
| MET2.2 | 19 | monthly | S/B |
| MET2.3 | 19 | monthly | S/B |
| MET3.1 | 19 | monthly | S/B |
| MET4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MET4.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE1.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE1.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE2.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MET5.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MET5.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE2.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MEE3.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE3.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MEE3.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MET6.1 | 19 | monthly | S/B |
| MET6.2 | 19 | monthly | 4 |
| MET7.1 | 19 | monthly | S/B |
| MET8.1 | 19 | monthly | S/B |
| MET9.1 | 19 | monthly | S/B |
| MET10.1 | 19 | monthly | S/B |
| Main Bay | | | |
| MCB1.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MCB2.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| MCB2.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB3.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |

(continued)

TABLE 6.1 (Continued)

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| MCB3.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB3.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB3.3E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB3.3W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.1E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.1W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB5.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB5.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB5.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB5.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.2E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.2W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.3E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| MCB4.3W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB5.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB5.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB5.2W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB7.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB6&7.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |

(continued)

TABLE 6.1 (Continued)

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| VCB6&7.2E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB6&7.2W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB6&7.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB6&7.3E | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB6&7.3W | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB7&8.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB7&8.1N | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VCB7&8.1S | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| Mobjack Bay | | | |
| VWE4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VWE4.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VWE4.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VWE4.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VWE4.5 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| Rappahannock River | | | |
| VTF3.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET3.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET3.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET3.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VLE3.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE3.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |

(continued)

TABLE 6.1 (Continued)

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| VLE3.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE3.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE3.5 | 19 | bi-monthly, Mar-June<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| York River | | | |
| VTF4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VTF4.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VTF4.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET4.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VLE4.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE4.2 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| VLE4.3 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| James River | | | |
| VTF5.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VTF5.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VTF5.3 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VTF5.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET5.1 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VRET5.2 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | S/B |
| VLE5.1 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |

(continued)

TABLE 6.1 (Continued)

| Station ID | Water Quality Parameters | Frequency | Depth Interval |
|---|---|---|---|
| VLE5.2 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| VLE5.3 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| VLE5.4 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE5.5 | 19 | bi-monthly, Mar.-May<br>monthly Nov.-Feb.<br>weekly June-Oct. | 4 |
| VLE5.6 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| VLE5.7 | 19 | bi-monthly, Mar-Oct.<br>monthly Nov.-Feb. | 4 |
| Atlantic Ocean | | | |
| VATL | 19 | monthly | 4 |

## WATER QUALITY SAMPLING

### Parameters

The nineteen water quality parameters to be taken at each station are:

- Temperature
- Dissolved Oxygen
- Secchi
- Salinity (Alkalinity in freshwater  0.5 ppt)
- pH
- Silicon
- Particulate organic carbon
- Dissolved organic carbon
- Total suspended solids (TSS)
- Total nitrogen and its constitutents
  - Dissolved total organic nitrogen
  - Particulate total organic nitrogen
  - Nitrate
  - Nitrite
  - Ammonia
- Total phosphorus and its constituents
  - Dissolved phosphorus
  - Total phosphorus
  - Orthophosphate
- Chlorophyll *a* (corrected and uncorrected) and Pheophytin *a*

### Frequency

Most sampling will be done on a monthly or bi-monthly basis as indicated on Table 6.1. A select group of stations that are near to the oyster spat sampling stations will be sampled weekly from mid-June to mid-October. All sampling frequencies should be analyzed statistically after two years to determine whether or not they may be decreased in some areas.

### Depth Intervals

Stations that are located in stratified areas will be sampled at four depths -- surface, 0.5 meters off the bottom and at some area above and below the pycnocline. The two latter sampling depths will have to be determined after the pycnocline profile has been identified. The rest of the stations will be sampled at surface and 0.5 meters off the bottom. In the tidal-fresh areas, as well as in some turbidity-zone areas, the surface and bottom sampling should be continued for at least one year, after which some statistical analyses should be done to determine whether or not a composite sample could be substituted for the discreet samples since these areas are usually less stratified than the lower estuarine and Bay segments.

### Sediment Sampling

Initially sediment samples will be taken at each water quality station annually and analyzed for metals, organics, total organic carbon content, grain size, and moisture content. It may be possible to reduce the frequency of sampling in many areas following several years of data acquisition and analysis.

### Biological Sampling

Finfish and oyster tissue will be sampled annually at selected stations and analyzed for metals, organic compounds, and moisture and lipid content. Analysis of finfish tissues from species with a more localized range is necessary if the source of the pollutant is to be found. These tissue analyses should be used as an indicator of whether or not there is a need to analyze for metals and organic compounds in the water column. When this becomes necessary, it is recommended that the National Bureau of Standards approach (Kingston et al. 1982) for measuring dissolved metals in the water column be used.

## Cost Analysis

This baseline program is structured to address the general questions which have arisen from the CBP research effort. The proposed program does not include other important monitoring efforts such as compliance monitoring, fecal coliform levels, and stock assessments.

The proposed monitoring strategy identifies 122 stations Bay-wide (an average of one station per 36 square miles) where samples are collected at 2 to 4 depths, 12 to 32 times per year. The proposed strategy includes 44 water column stations in the Maryland tributaries, 22 in the main Bay of Maryland, 42 in the Virginia tributaries, and 15 stations in the main Bay of Virginia. Presently, there are 4 water column stations sampled in the tributaries of Maryland, 3 stations in the Maryland main Bay, and 199 stations in the Virginia tributaries.

Cost estimates for the proposed program are as follows:

TABLE 6.2. COST ESTIMATES

| | No. Samples/Year | Cost/Year ($) |
|---|---|---|
| Water Column[1] | | |
| Maryland Tributaries | 1,840 | 349,600 |
| Maryland Main Bay | 1,680 | 319,200 |
| Virginia Tributaries | 2,680 | 509,200 |
| Virginia Main Bay | 1,168 | 221,920 |
| Subtotal | | 1,400,000 |
| Sediments[2] | | |
| Maryland Tributaries | 44 | 44,000 |
| Maryland Main Bay | 22 | 22,000 |
| Virginia Tributaries | 42 | 42,000 |
| Virginia Main Bay | 15 | 15,000 |
| Subtotal | | 123,000 |
| Biology[3] | | |
| Maryland | | |
| Juv. Finfish Index | 132 | 26,040 |
| Shellfish Contam. | 66 | 79,000 |
| Oyster Spat | 60 | 19,900 |
| Virginia | | |
| Juv. Finfish Index | 624 | 7,296 |
| Shellfish Contam. | 57 | 68,000 |
| Oyster Spat | 49 | 13,200 |
| Subtotal | | 213,436 |
| TOTAL | | \$1,740,000 |

---

1. Water Column
\$150/sample analysis
\$ 40/sample collection
\$190/sample
Water column samples will be analyzed for temperature, dissolved oxygen, light penetration (Secchi), salinity, pH, silica, dissolved organic nitrogen, particulate nitrogen, nitrite, nitrate, ammonia, total dissolved phosphorus, total particulate phosphorus, orthophosphate, chlorophyll _a_, pheophytin _a_, particulate organic carbon, dissolved organic carbon, and total suspended solids.

2. Sediment
\$950/sample analysis
\$ 50/sample collection
\$1000/sample
Sediment samples will be analyzed for organics, metals, TOC, grain size, and % moisutre.

3. Tissue \$1200/sample
Shellfish tissue samples will be analyzed for organics, metals, % moisture, and % lipid.

## Funding Considerations

The cost of implementing a baseline nutrient monitoring plan to provide data to make trend assessments is substantial. Efforts focused on levels II and III (i.e., correlations and causal inference) will require special studies and associated costs. Thus, it is suggested that the states accept responsibility for monitoring work in the tributaries of the Bay with existing Federal support and that a more significant Federal contribution be made to monitoring the main stem of Chesapeake Bay. The rationale for this proposal is derived from the shared boundaries of the main stem of the Bay by the States of Maryland and Virginia and the role of Chesapeake Bay as a national resource.

# ATTACHMENT 7
# A SUGGESTED MONITORING/MANAGEMENT STRATEGY FOR NUTRIENTS, OXYGEN AND OYSTERS IN THE MAIN STEM OF CHESAPEAKE BAY

## PROBLEM

Low levels of dissolved oxygen are occurring with increasing frequency, extent and duration in the deep channel of the mid-Chesapeake Bay.

## RATIONALE

Dissolved oxygen has long been recognized as a critical factor, especially in aquatic environments. All aerobic forms, essentially all "higher organisms," have survival limits to exposure of oxygen shortages. Many deep-ocean basins, eutrophic lakes and estuaries with deep channels, and strong vertical salinity gradients typically develop low DO levels during the summer when water temperatures are high. The Chesapeake Bay is no exception and probably through natural processes has exhibited low summer DO levels early in its geological history.

During those years in the summer to early fall when natural hydrographic conditions and anthropogenic inputs facilitate anoxic conditions, the majority of fish and shellfish species would be excluded by potential lethal conditions from about 20 percent of the deeper waters of the mid-Bay area, but very likely by behavioral avoidance from about 60 percent of the mid-Bay waters, leaving only shallow surface waters (2 to 3 meters) for feeding and spawning. Anecdotal evidence from fishermen and scientists indicate that there have been increasing instances of oyster mortalities and "crab wars" or "jubilees" caused by low dissolved oxygen in recent years; however, data are not readily available which allow site specific descriptions of the problem, particularly outside of the main channel of the Bay from Gibson Island to Tangier Island.

Present concern is that anthropogenic activities are exacerbating the problem (Flemer et al. 1983). An increased nutrient supply is probably contributing to an increased production of organic matter by phytoplankton. This material settles into the deep channel where decomposition processes can out-strip physical processes of reaeration and mixing of surface waters containing higher levels of DO with deep waters.

The low DO in the deep channel can be approached conceptually in terms of sources of nutrients, transport of nutrients and organic matter, and effects of production and decomposition processes.

## SPECIFIC QUESTION

Is the longitudinal, lateral and vertical extent, and duration of low levels of DO continuing to increase in the deep channel region of Chesapeake Bay?

Proposed management and monitoring strategy:

1. The extent and duration of the hypoxic events should be characterized by oxygen analyses that provide spatial and temporal coverage to include:

   a. All areas of the Bay and tributaries which have depths greater than four meters ($\approx$ 12 feet) which are the depths most drastically affected in the main channel of the Bay.

   b. Coverage at least during the period of May to October when the problem is greatest.

   c. Carefully establish diurnal ranges and models for predicting them recognizing that the severest oxygen depletion is likely to occur just before dawn whereas most oxygen sampling has traditionally been conducted during daylight hours.

2. Ambient oxygen levels and duration of exposure should be compared to the laboratory established tolerances for various species of endemic animals. The EPA-established criteria for the minimum concentration of dissolved oxygen to maintain good fish populations in open waters is 5.0 mg $L^{-1}$ (3.6 ml $L^{-1}$). All available evidence from the scientific literature for local freshwater, estuarine, and marine fish and shellfish support this criterion.

   (Note: Productive SAV beds probably have early morning DO values of less than 5.0 mg $L^{-1}$.)

3. Formulate specific control strategies to reduce nutrient and carbon input into the system sufficiently to return the majority of the Bay and tributary waters to the established EPA criterion of 5.0 mg $L^{-1}$ (3.6 ml $L^{-1}$) dissolved oxygen. Monitor to determine if the following occurs: reduction in point and nonpoint source loadings; reduction in ambient levels of nutrients and carbon within the Bay and its tributaries; reduction in hypoxic conditions within the Bay and its tributaries; improvement in utilization of previously affected habitat by endemic species in question; and improvement of fisheries in question.

The following sample strategy is offered as a guide to assess the effects of nutrient concentrations on the oyster as a key indicator of natural resources and the influence on nutrients, oxygen, and oysters that the implementation of nutrient controls might have on hypoxic conditions and oyster populations in Chesapeake Bay.

I. Working Hypothesis -- Increases in plant nutrient levels (expressed as total nitrogen and total phosphorus) are contributing to an increasing eutrophication of Chesapeake Bay which is being expressed as an ever growing volume of low oxygen (hypoxic) water in the deeper portions of the main stem of Chesapeake Bay (Patapsco River to Tangier Island) and its tributaries. Although the occurence of low oxygen in the deeper portions of the Bay and some tributaries has been recognized for many years and was thought to be a natural phenomenon (e.g., the anoxic conditions that have led to the "black muds" in the deep channel of the lower Rappahannock estuary).[4] There is evidence that the depth and volume of these hypoxic waters have been expanding during the last two decades and have begun to seriously encroach upon oyster beds, causing mortality of oysters either by suffocation or by stressing the animals and, thus, making them more susceptible to oyster diseases such as MSX (Figure 7.1).

II. Worst Case Goal -- To halt the nutrient enrichment of Chesapeake Bay and to maintain the present biological productivity and distribution of oysters in the Bay.

III. Best Case Goal -- To reduce the ambient levels of plant nutrients in Chesapeake Bay to levels observed during the early 1950's in an effort to restore water oxygen concentrations and the availability of oyster habitat to conditions circa 1950.

IV. Models and relationships required for establishing target loads and effectiveness of management strategies--

A. Relationship of land use to nutrient loads by basin and sub-basin.

B. Relationship of land use to nutrient loads at the fall line of major Chesapeake Bay tributaries.

C. Relationship of nutrient loads at the fall line to ambient nutrient and oxygen levels at several depths in CB-1, CB-2, CB-3, CB-4, and CB-5. This would require a mathematical model of CB 1-5 that provides output describing vertical structure.

[Note: it may not be feasible to establish such relationships in CB-1 and CB-2 for a variety of reasons (e.g., resuspension of bottom sediments).]

D. Nutrient fluxes through the boundaries of the system (CB 1-5) which would include fall lines, surface transfer, benthic (bottom) transfer, tributary river input, sewage treatment plant input, and down-Bay oceanic transfer between CB-5 and CB-6.

(Caution: above processes need better description and sensitivity analysis before "blindly" applying a water quality model.)

E. Model runs for various present condition, future condition, and proposed nutrient removal strategies at the fall line and in CB 1-5.

V. Information and data presently collected that would support this monitoring effort--

A. Fall line monitoring of nutrients and river flow.

B. Standard meteorological observations from representative locations including air temperature, precipitation, wind speed and direction, etc.

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[4] Personal Communication: "Anoxic Conditions in the Deep Channels," J. Andrews, VIMS, 1983.

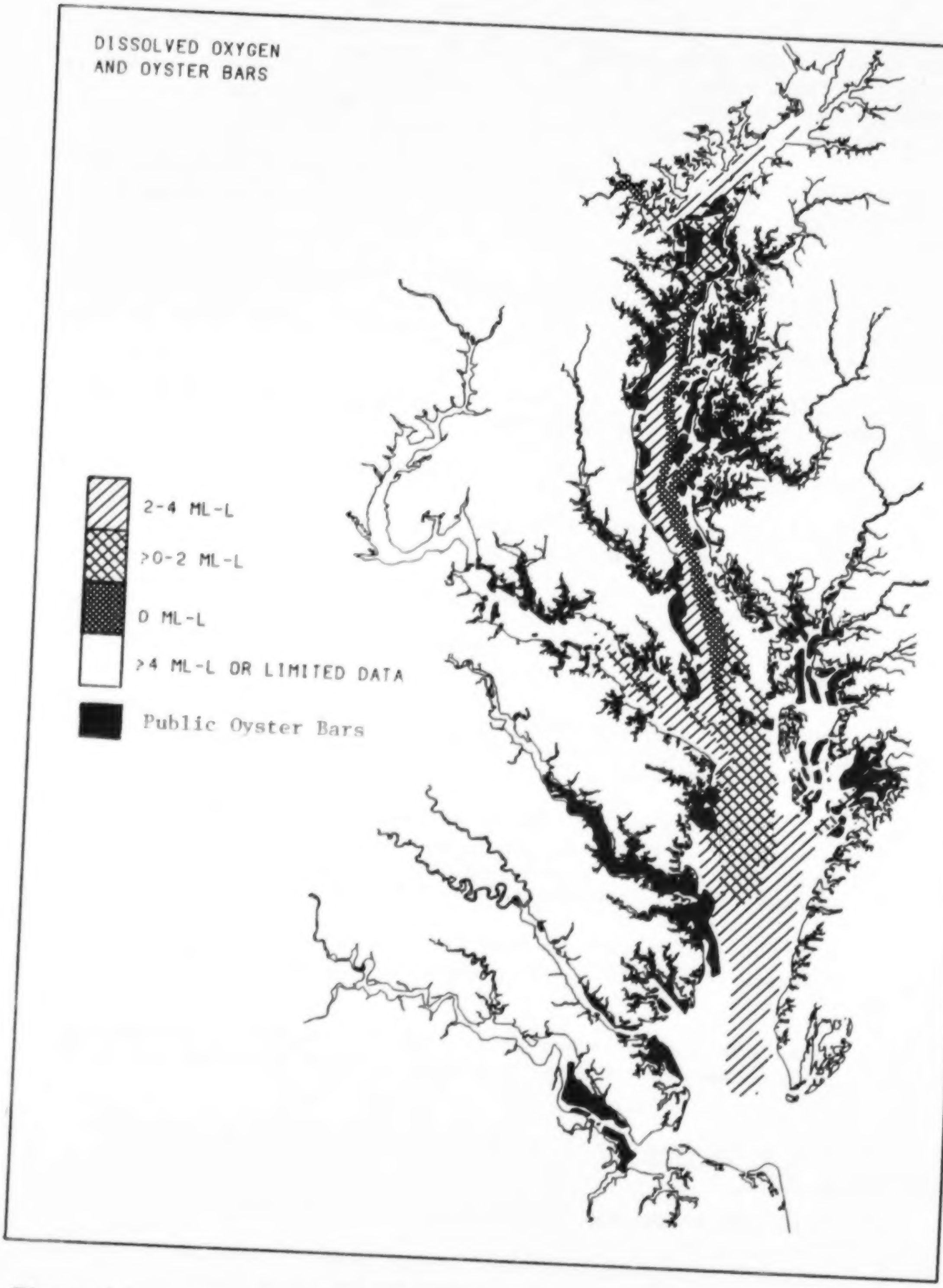

Figure 7.1. Areas of reduced dissolved oxygen concentrations relative to the location of public oyster bars.

C. STP and industrial discharges of nutrients in pertinent tributaries.

D. Land use described in the categories (e.g., forest, conventional tillage, no-till, etc.) necessary to support land use/nutrient loading model as described in IV-B above.

E. Fertilizer use by basin or sub-basin.

F. Basic hydrographic observations including salinity, water temperature, tide stage, current velocity, etc.

VI. Information and data needed but presently not collected in a systematic and uniform manner to support this monitoring effort--

A. Ambient nutrient levels on a vertical and horizontal scale measured every two weeks in CB 1-5 to predict monthly, seasonal, and annual means and variances.

B. Ambient oxygen levels on a vertical and horizontal scale measured monthly in CB 1-5 to predict time of onset, decline, and monthly, seasonal, and annual means and variances, and seasonal cycles.

C. Ambient oxygen levels on a vertical and horizontal scale measured at least hourly at worst case conditions in CB 1-5 to predict diurnal cycles and during a representative wet, dry, and typical year.

D. Quarterly collected box cores and dredge or diver samples with synoptic coverage of the floor of CB 1-5 to predict benthic species diversity and mortality with special consideration given to mortality, spat set, disease, and general condition of the oyster.

E. Bioassays conducted in live boxes (pearl nets, trays, etc.) on a vertical and horizontal scale under worst case oxygen conditions using oysters, crabs and representative finfish (*M. saxatilis*, *Menidia* and *Fundulus*) to verify oxygen exposure levels that cause mortality and perhaps stress using a physiological indicator (e.g., oxygen debt).

VII. Statistical and sampling design considerations--

A. Models relating either ambient oxygen levels or ambient nutrient levels to land use must have the sensitivity and accuracy to detect, at the minimum, a ten percent reduction in load in terms of detectable changes in ambient concentrations.

B. Field sampling programs for ambient nutrient and oxygen levels must be designed statistically to calibrate and verify the models.

C. Benthic species sampling frequency should be determined by past practice and acceptable standards for determining species diversity (Kaufman et al. 1980).

D. Sampling for oyster spat set, oyster mortality, and oyster condition should be conducted using the procedures of Haven (VIMS), Krantz (U. MD), and Otto (MD DNR).

E. Nutrient and oxygen data in the CBP computer data base should be analyzed to estimate sampling frequency and intensity necessary to determine year-to-year differences. This analysis would be used to determine sampling frequency and intensity and to develop a stratified random approach to sampling plans.

F. George Krantz and James Salevan (CEES) have analyzed spat set and adult oyster surveys to estimate the sampling frequency and intensity necessary to detect differences on various beds. This analysis should be used to determine sampling frequency and intensity necessary to show statistical differences on beds or portions of beds.

G. Synoptic data should meet the usual statistical constraints.

## VIII. Station locations--

A. The EPA's Chesapeake Bay Program prepared a chart that overlays the distribution of oyster bars in CB 1-5 with dissolved oxygen distributions (contours) for the summer of 1980 for the concentrations of 0, 0 to 2, 2 to 4, and 4 ml $L^{-1}$ (Figure 7.1). This chart was used to assist in locating water quality and biological sampling stations in areas where station coverage should be maximized to allow detection of the encroachment of hypoxic water onto oyster bars. These areas are where the 2 to 4 ml $L^{-1}$ of dissolved oxygen for 1980 is in close proximity to productive bars that are located on a fairly shallow slope (i.e., where a small change in the amplitude of low oxygen will cover a large area of shoal or bar). It was concluded that to provide for historical analysis and an appropriate scope of coverage, the core hydrographic, nutrient, and oxygen sampling stations should be the same as those previously used by the Chesapeake Bay Institute (CBI) in their studies (Figure 7.2).

## IX. Number of stations and sampling frequency--

These parameters are based initially on statistical considerations for detecting change but will be adjusted to match the expected resources for conducting this monitoring effort.

## X. Sampling strategies--

A. Bi-monthly ambient $O_2$ levels

1. Transects across the Bay, each approximately twenty nautical miles apart, would be occupied bimonthly to determine the extent and depth of the hypoxic conditions (Figure 7.2). These transects should be located to pass through historical CBI hydrographic stations.

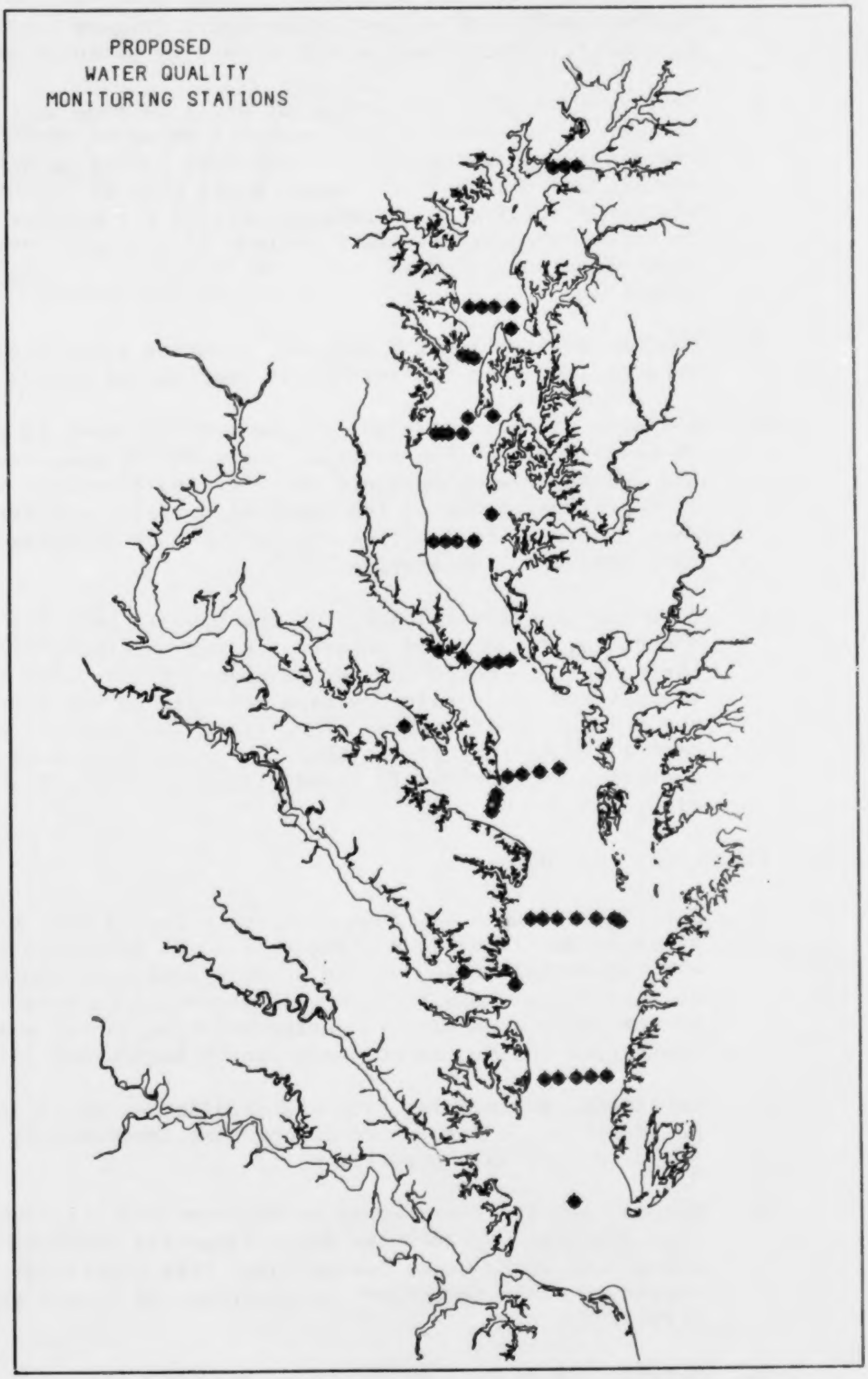

Figure 7.2. Proposed stations for level III oyster/DO study.

2. On each transect the ship would occupy stations that are approximately 2.5 nautical miles apart (Figure 7.2). Presumably, positioning would be done by Loran or radar.

3. Measurements of $O_2$ concentration would be done at each station at two-meter depth intervals using an oxygen electrode type meter that is resistant to $H_2S$ poisoning. A surface and bottom water sample would also be taken at each station according to methods prescribed for Winkler titration in order to calibrate the electrode at each station. All depth intervals measured would be indicated in terms of height from the bottom and depth from the surface.

4. Maximum positioning and sampling location error should be held to less than $\pm$ 5 percent on spacing and depth.

5. Assuming the area covered (Figure 7.2) is about 60 stations x 10 meter depth on the average, some 1800 $O_2$ measurements and 720 water samples would be collected bimonthly during the first several years of the sampling program. An attempt should be made to describe the behavior of dissolved oxygen in a wet, dry, and average flow year.

6. Once the behavior and shape of the hypoxic pool was described, it would be possible to reduce effort and concentrate on detecting the movement of the outer edge of the hypoxic pool, using perhaps one-half to one quarter of the initial measurements. The edge of the hypoxic pool would be defined as that region where the most pronounced ecological effects would occur (i.e., an oxygen concentration of 0.5 to 3.0 ml $L^{-1}$).

B. Diurnal ambient $O_2$ levels

1. A minimum of five stations would be selected from X.A.2. sites as described above (Figure 7.2) to determine vertical and horizontal motion of the hypoxic pool on a short-term and diurnal basis. One station would be selected from the center of the study area with two being selected as the east/west boundaries and two as the north/south boundaries (Figure 7.2).

2. Equipment, positioning, and standardization procedures would be identical to X.A. above except that instrumental buoys would be used when possible.

3. Oxygen concentrations would be measured simultaneously at all five stations at two-meter depth intervals continuously for the period of 72 hours during worst case conditions (late August to early September) as described by Flemer and Biggs (1971).

4. Behavior of diurnal $O_2$ should be determined at worst case conditions under high flood, drought, and spring and neap tide conditions, and a range of meterological conditions on the continental shelf that may affect mid-Bay vertical

stratification and mixing processes to provide some measure of variance in the system.

C. Bi-monthly ambient nutrient levels

1. Stations at the end of each transect as well as the central stations represented by the CBI historical hydrographic stations and others on the same line as described in X.A.2. above would be occupied as nutrient stations (Figure 7.2) on a monthly basis.

2. At each nutrient station, water samples would be collected at the surface, bottom, at the pycnocline, and two meters above and below the pycnocline depth. These samples would be stored and analyzed according to standard methods for total phosphorus (and its component compounds), total nitrogen (and its component compounds), chlorophyll a, and total carbon (and particulate and dissolved organic carbon).

D. Auxillary hydrographic data collection

1. Salinity and temperature of the water sampled would also be measured using standard CTD techniques wherever nutrient or oxygen concentrations are measured in the field. Primary productivity would be measured using standard techniques involving light and dark bottle dissolved oxygen as described by Flemer and Olmon (1971) at selected CBI core stations. Special attention should be given to dark bottle respiration rates.

E. Benthic fauna mortality studies

1. The work of Holland et al. (1977) and Kaufman et al. (1980) have shown that muddy areas below ten meters in the vicinity of Calvert Cliffs and Taylors Island suffer almost total faunal depletion every summer as a result of near anoxic stress. Therefore, quarterly standardized Van Veen samples for benthic fauna and patent tong samples for oysters collected at each station location identified in X.A.2. (Figure 7.2) would suffice to indicate the presence or absence of a typical aerobic benthic community.

2. If one desired to study species diversity and faunal differences among aerobic stations as an auxillary to the study of the effects of hypoxia, it would be important to design sampling strategies based on the work of Kaufman et al. (1980) which would require much more intensive sampling.

3. Spat set studies would be accomplished by suspending clean shell on "shell strings" suspended at one-foot intervals at 40 stations that are representative of oyster growing areas (Figure 7.1). These shell strings would be suspended from surface to bottom in a fashion perpendicular to the bottom one week prior to an expected major set for the season (probably during July) and recovered for final counting in

late September. The strings would be pulled every two weeks to estimate spat set and early mortality and redeployed immediately. A second set of strings would be deployed fresh and recovered at each station for counting in the laboratory at two week intervals during the period of July to September. A comparison of the results of the short and long-term "strings" will provide evidence of short-term mortality and inhibition of setting by hypoxic water as compared to the mortality of spat which may be set for sometime and then killed by hypoxic water.

F. Bioassays

1. Bioassay studies would be conducted in conjunction with diurnal oxygen studies as described in X.B.1-3. above.

2. Fresh live oysters (1 to 2 years old), fresh live crabs (1 to 2 years old), and 2 to 3 inch Fundulus heteroclitus (mummichog) and Menidia menidia (Atlantic silversides) would be collected from areas having relatively low environmental stress. The animals would be held in live cans (or laboratory tanks) for one week acclimation period at the approximate temperature and salinity of expected exposure but in water having 90 to 100 percent $O_2$ saturation.

3. Twenty animals of each species would be placed in a separate "pearl-net" type of enclosure for field testing.

4. "Pearl-net" type of enclosures, each containing 20 individuals of a single species, would be attached to a vertical warp at four meter intervals. One end of the warp would be anchored to the bottom while the other end would be buoyed in a fashion to achieve an arrangement where the nets are suspended on a line perpendicular to the bottom with sets of 20 animals located at four meter intervals from the bottom to the surface. Oxygen measurements in X.B.3. would be arranged at the same levels as the deployment of the test animals. Effects on fish behavior of caging experiments should be evaluated.

5. At the end of a 72 hour exposure period the nets would be retrieved. Those animals remaining alive would be counted and placed in respirometers separated according to depth of exposure and species where temperatures and salinity are equivalent to field exposure and their oxygen consumption measured in an effort to detect evidence of oxygen debt. Dead animals would be counted for the purpose of calculating mortality rates at the various $O_2$ concentration exposure levels.

6. At two week intervals, during the crab potting season, aerial photography would be used to document the location of crab pots which tend to be fished further inshore in more shallow water as fishermen find dead crabs in their pots presumably due to low dissolved oxygen in deep water.

# ATTACHMENT 8

# A DESCRIPTION OF THE SUBMERGED AQUATIC VEGETATION IN THE UPPER CHESAPEAKE BAY FROM 1971 TO 1981 AND THE RESULTING MANAGEMENT AND MONITORING RECOMMENDATIONS

## INTRODUCTION

Submerged aquatic vegetation (SAV) is in many ways vital to the Chesapeake Bay's biological, chemical, and physical function (Stevenson and Confer 1978). Therefore, it is reasonable that Chesapeake Bay should be managed in part to ensure SAV abundance and quality. Although Chesapeake Bay SAV has been of general interest for a number of years, a variety of Bay-wide problems are specifically related to or involved with the management of the Bay's SAV. A few of these problems are: the introduction of alien SAV species, a decrease in the density of waterfowl accompanying the SAV decrease, nutrient eutrophication, and herbicide runoff impacts (Stevenson et al. 1979). These concerns stimulated the U.S. Fish and Wildlife Service (USFWS) and the Maryland Department of Natural Resources (MDNR) to conduct a monitoring program that would provide information regarding the upper Chesapeake Bay's SAV community. This monitoring program began in 1971; analyses of the resultant data have helped to document changes in Chesapeake Bay's SAV.

The first analysis of the USFWS/MDNR SAV monitoring data was reported by Kerwin et al. (1975a) and involved an examination of the years 1971 to 1973 to assess the impact of the 1972 Tropical Storm Agnes on Chesapeake Bay's SAV. Kerwin et al. (1975b) also reported on the monitoring program from 1971 to 1974. Stevenson and Confer (1978) described the SAV data base from 1971 through 1976 by species, drainage basin, and year. Stevenson et al. (1979) present the percentage of stations vegetated each year from 1971 through 1978. Munro (1976a) compared the SAV in 1975 with that in 1971 through 1974 and also (1976b) compared the SAV in 1976 with that in 1971 through 1975. Munro and Perry (1981) used the SAV monitoring data from 1971 through 1980 and explored the relationship of SAV changes to trends in waterfowl distribution and food habits. Finally, Flemer et al. (1983), as part of the EPA's-Chesapeake Bay Program characterization report, used the SAV monitoring data from 1971 through 1981 to determine, for each year, the percent of stations that had vegetation and used this percentage as an index to monitor changes in SAV during the 1970's.

The purpose of this attachment is to use a descriptive analysis of the SAV monitoring data from 1971 through 1981 to assist in making recommendations regarding the future monitoring and management of SAV in the upper Chesapeake Bay. Monitoring recommendations focus upon how to increase the efficiency of the sampling effort and maintain consistency with the previous eleven years of data. The management recommendations are based on an analysis of the relationship between the SAV and geographical, temporal, and environmental factors.

## METHODS

The USFWS/MDNR monitoring of the upper Chesapeake Bay (all of Maryland's waters except the Potomac River) SAV has been conducted in a similar manner for eleven years (1971 to 1981) at approximately 640 stations. Each station was visited once a year in late summer or early fall. On each visit, the date, location, water depth, secchi disk depth, surface water termperature, and surface salinity were recorded. Three replicate vegetation samples were also taken on each visit. Percent composition of each species in the sample was estimated by inspection, and the volumetric displacement of the total sample was measured to the nearest cubic centimeter. The field methodology is described in detail in Kerwin et al. (1975a).

The monitoring program has provided data that include two categories of variables: SAV community and descriptive. The descriptive variables can be sub-categorized into class variables and numeric variables. The class variables, which identify the location and time of sample, are Chesapeake Bay Program (CBP) segment (Figure 5), station location within the CBP segment, replicate identification, and year. The numeric environmental variables were measured on nearly every station visit and provided a measure of the SAV habitat at the time of sampling. They are: secchi disk depth (cm), salinity (ppt), surface temperature (°C), and water depth (m). Secchi disk depth is an index of light penetration into the surface of the water column. However, it is important to emphasize that light penetrates beyond the secchi disk depth. An additional numeric descriptive variable was calculated in this analysis by subtracting secchi disk depth from water column depth; this variable is referred to as WC-SD and is a measure of the depth of water below the secchi disk depth. In shallow water systems (less then 4m), some light always penetrates to the bottom; WC-SD serves as an index of how much light the bottom is receiving.

Three sub-categories of SAV community variables were measured. The first is the total volumetric displacement of the SAV contained in one replicate sample from a station. Volumetric displacement is measured as a volume of vegetative material per area of water bottom and has been converted to and analyzed as cubic centimeters per square meter (cc/m). Another sub-category that describes the SAV community is the relative abundance of each species. These variables, one variable for each of the species or unidentified plant types that were found, were recorded for each replicate sample as percentages but have been transformed to measures of presence or absence for use in this attachment. The 28 plant categories include vascular plants, macroalgae, and unidentified plant material (Table 8.1). The final sub-category of SAV community variables is the number of species of vascular plants and the number of species of macroalgae found in a replicate sample.

## RESULTS

This section describes the data base resulting from the eleven years of monitoring the Chesapeake Bay SAV and selected environmental variables. The environmental variables (year, CBP segment, water column depth, secchi disk depth, WC-SD, salinity and temperature) are first described independently (Tables 8.2 and 8.3). The SAV community is then described independently

TABLE 8.1. A LISTING OF THE SUBMERGED AQUATIC VEGETATION ENCOUNTERED IN THE CHESAPEAKE BAY FROM 1971 to 1981

| Species | Vascular Plants[1] | Macro-Algae[1] |
|---|---|---|
| 1. Redhead grass (Potamogeton perfoliatus) | | |
| 2. Widgeongrass (Ruppia maritima) | X | |
| 3. Eurasian watermilfoil (Myriophyllum spicatum) | X | |
| 4. Eelgrass (Zostera marina) | X | |
| 5. Sago pondweed (P. pectinatus) | X | |
| 6. Horned-pondweed (Zanichellia palustris) | X | |
| 7. Wildcelery (Vallisneria americana) | X | |
| 8. Common elodea (Elodea canadensis) | X | |
| 9. Naiad (Najas guadalupensis) | X | |
| 10. Muskgrass (Chara spp.) | X | |
| 11. Slender pondweed (P. pusillus) | | X |
| 12. Coontail (Ceratophyllum demersum) | X | |
| 13. Unidentified fragments | X | |
| 14. Curly pondweed (Potamogeton crispus) | X | |
| 15. Sea lettuce (Ulva spp.) | X | |
| 16. Agardhiella spp. | | X |
| 17. Unidentified filamentous green algae | | X |
| 18. Unidentified green algae | | X |
| 19. Gracilaria spp. | | X |
| 20. Water-stargrass (Heteranthera dubia) | X | |
| 21. Unidentified alga | X | |
| 22. Enteromorpha spp. | | X |
| 23. Ceramium | | X |
| 24. Polysiphonia | | X |
| 25. Dasya spp. | | X |
| 26. Unidentified red alga | | X |
| 27. Unidentified brown alga | | X |
| 28. Champia parvula | | X |
| | | X |

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[1] An "X" in the column indicates the type of SAV.

TABLE 8.2. A BAY-WIDE SUMMARY BY YEAR OF THE ENVIRONMENTAL VARIABLES MEASURED DURING THE MONITORING OF UPPER CHESAPEAKE BAY SAV

| Year | Water Column Depth (m) | Secchi Disk Depth (cm) | WC-SD (m) | Salinity (ppt) | Surface Temp (°C) |
|---|---|---|---|---|---|
| 1971 | 1.54 | -- | -- | 13.8 | 24.1 |
| | (0.03) | | | (0.31) | (0.15) |
| 1972 | 1.53 | 66.3 | .87 | 9.4 | 21.6 |
| | (0.03) | (1.34) | (0.03) | (0.28) | (0.33) |
| 1973 | 1.60 | 71.0 | .88 | 10.2 | 26.8 |
| | (0.03) | (1.10) | (0.03) | (0.26) | (0.08) |
| 1974 | 1.52 | 79.6 | .72 | 12.3 | 25.4 |
| | (0.03) | (1.30) | (0.03) | (0.03) | (0.06) |
| 1975 | 1.59 | 75.9 | .83 | 11.0 | 25.0 |
| | (0.03) | (1.92) | (0.03) | (0.20) | (0.14) |
| 1976 | 1.47 | 71.3 | .75 | 8.0 | 27.0 |
| | (0.03) | (1.01) | (0.02) | (0.19) | (0.07) |
| 1977 | 1.31 | 67.0 | .65 | 11.0 | 27.7 |
| | (0.03) | (0.96) | (0.02) | (0.18) | (0.20) |
| 1978 | 1.46 | 73.9 | .72 | 8.5 | 27.2 |
| | (0.03) | (1.24) | (0.02) | (0.19) | (0.10) |
| 1979 | 1.50 | 71.1 | .79 | 7.4 | 28.1 |
| | (0.03) | (0.99) | (0.03) | (0.22) | (0.09) |
| 1980 | 1.48 | 67.2 | .81 | 11.0 | 28.1 |
| | (0.03) | (0.91) | (0.02) | (0.23) | (0.07) |
| 1981 | 1.48 | 64.6 | .91 | 12.1 | 25.7 |
| | (0.03) | (0.94) | (0.03) | (0.22) | (0.10) |

NOTES:

1. All values not in parentheses are averages of all values of a particular environmental parameter measured during that year of sampling. Secchi disk depth was not measured in 1971.

2. All values in parentheses are standard errors.

3. Definitions:

   (a) Water Column Depth is the distance from the water surface to the bottom.
   (b) Secchi Disk Depth is the distance from the water surface to the depth where a secchi disk first disappears as it descends through the water column.
   (c) WC-SD is the Water Column Depth minus Secchi Disk Depth.
   (d) Salinity is a measure of the salt concentration. If it was measured as less than or equal to one then it has been set to zero.
   (e) Surface Water Temperature is a measure of water temperature in the top several cm of the water column.

TABLE 8.3. A SUMMARY BY CBP SEGMENT OF THE ENVIRONMENTAL VARIABLES MEASURED DURING THE 1971 TO 1981 MONITORING OF UPPER CHESAPEAKE BAY SAV

| CBP Segment | Water Column Depth (m) | Secchi Disk Depth (cm) | WC-SD (m) | Salinity (ppt) | Surface Water Temperature (°C) |
|---|---|---|---|---|---|
| CB-1 | 1.57 | 71.7 | 0.83 | 0.63 | 22.6 |
| | (0.03) | (1.84) | (0.04) | (0.09) | (0.55) |
| CB-2 | 1.13 | 42.6 | 0.70 | 1.93 | 27.5 |
| | (0.03) | (1.37) | (0.03) | (0.23) | (0.17) |
| CB-3 | 1.50 | 78.9 | 0.70 | 6.90 | 26.2 |
| | (0.04) | (2.37) | (0.04) | (0.25) | (0.21) |
| CB-4 | 1.65 | 77.7 | 0.88 | 12.9 | 26.5 |
| | (0.03) | (1.30) | (0.48) | (0.19) | (0.12) |
| CB-5 | 1.72 | 88.4 | 0.83 | 15.1 | 25.4 |
| | (0.03) | (1.61) | (0.03) | (0.14) | (0.13) |
| EE-1 | 1.19 | 67.7 | 0.50 | 10.9 | 27.4 |
| | (0.03) | (1.24) | (0.03) | (0.17) | (0.11) |
| EE-2 | 1.21 | 66.8 | 0.52 | 11.4 | 27.4 |
| | (0.02) | (0.93) | (0.02) | (0.15) | (0.10) |
| EE-3 | 1.85 | 77.7 | 1.07 | 15.2 | 25.2 |
| | (0.02) | (0.73) | (0.02) | (0.12) | (0.09) |
| ET-1 | 1.92 | 49.1 | 1.39 | 0.47 | 21.8 |
| | (0.08) | (1.67) | (0.08) | (0.16) | (1.27) |
| ET-2 | 1.38 | 36.2 | 1.05 | 0.53 | 26.7 |
| | (0.05) | (1.08) | (0.05) | (0.09) | (0.27) |
| ET-3 | 1.31 | 46.4 | 0.86 | 0.63 | 27.5 |
| | (0.05) | (1.64) | (0.05) | (0.14) | (0.36) |
| ET-4 | 1.38 | 70.2 | 0.69 | 8.57 | 27.5 |
| | (0.04) | (2.40) | (0.04) | (0.18) | (0.09) |
| ET-5 | 1.26 | 61.8 | 0.63 | 7.57 | 27.1 |
| | (0.04) | (1.86) | (0.04) | (0.27) | (0.19) |
| ET-6 | 1.48 | 49.0 | 0.99 | 10.1 | 25.2 |
| | (0.37) | (0.90) | (0.05) | (0.33) | (0.23) |
| ET-7 | 1.60 | 62.7 | 1.01 | 11.8 | 24.9 |
| | (0.06) | (1.54) | (0.06) | (0.28) | (0.24) |
| ET-8 | 1.70 | 86.6 | 0.81 | 16.1 | 25.1 |
| | (0.07) | (2.76) | (0.06) | (0.35) | (0.24) |
| ET-9 | 1.51 | 88.8 | 0.58 | 16.7 | 24.4 |
| | (0.07) | (2.65) | (0.06) | (0.34) | (0.28) |
| LE-1 | 1.46 | 76.9 | 0.69 | 12.7 | 27.3 |
| | (0.04) | (1.41) | (0.04) | (0.27) | (0.32) |
| TF-1 | 1.13 | 40.0 | 0.71 | 4.0 | 25.8 |
| | (0.07) | (1.35) | (0.07) | (0.47) | (0.89) |
| RET-1 | 1.22 | 48.9 | 0.68 | 8.5 | 26.1 |
| | (0.06) | (1.71) | (0.05) | (0.50 | (0.85) |
| WT-1 | 1.36 | 44.0 | 0.92 | 1.3 | 26.6 |
| | (0.06) | (2.01) | (0.06) | (0.26) | (0.61) |
| WT-2 | 0.94 | 41.9 | 0.52 | 1.4 | 26.1 |
| | (0.06) | (2.88) | (0.06) | (0.30) | (0.61) |

(continued)

TABLE 8.3 (Continued)

| CBP Segment | Water Column Depth (m) | Secchi Disk Depth (cm) | WC-SD (m) | Salinity (ppt) | Surface Water Temperature (°C) |
|---|---|---|---|---|---|
| WT-3 | 1.15<br>(0.05) | 64.5<br>(3.14) | 0.52<br>(0.05 | 2.5<br>(0.30) | 27.7<br>(0.22) |
| WT-4 | 1.26<br>(0.05) | 31.4<br>(1.34) | 0.94<br>(0.05) | 1.19<br>(0.25) | 27.4<br>(0.24) |
| WT-5 | 1.41<br>(0.04) | 64.6<br>(1.62) | 0.76<br>(0.04) | 5.50<br>(0.31) | 28.2<br>(0.16) |
| WT-6 | 1.18<br>(0.28) | 75.6<br>(3.02) | 0.44<br>(0.06) | 8.0<br>(0.49) | 27.6<br>(0.22) |
| WT-7 | 1.07<br>(0.04) | 76.9<br>(2.04) | 0.29<br>(0.04) | 8.0<br>(0.42) | 27.4<br>(0.10) |
| WT-8 | 1.31<br>(0.06) | 59.7<br>(2.2) | 0.71<br>(0.06) | 9.3<br>(0.51) | 28.1<br>(0.19) |

NOTES:

1. All values not in parentheses are averages of all values of a particular environmental parameter measured in the CBP segment during the 1971-1981 sampling.
2. All values in parentheses are standard errors.
3. Definitions:
    a. Water Column Depth is the distance from the water surface to the bottom.
    b. Secchi Disk Depth is the distance from the water surface to the depth where a secchi disk first disappears as it descends through the water column.
    c. WC-SD is the Water Column depth minus Secchi Disk Depth.
    d. Salinity is a measure of the salt concentration. If it was measured as less than or equal to one then it has been set to zero.
    e. Surface Water Temperature is a measure of water temperature in the top several cm of the water column.

(Tables 8.4 and 8.7) and as a function of the descriptive variables (Tables 8.5, 8.6, and 8.8 to 8.15).

## Environmental Variable Trends

Surface water temperature did not vary considerably over time except in 1972 when temperatures were lower than other years by a range of 1.5 °C to 6.5 °C (Table 8.2). This was possibly due to cooler and larger freshwater inflow from Tropical Storm Agnes, which passed through the area in June 1972 just prior to sampling; salinity was also low that year (Table 8.2). Freshwater inflow appears to influence temperatures in the northern bay as seen by the lower temperature of 22.6 °C in the northern-most open Bay segment, the Susquehanna Flats (CB-1), and the lower temperature of 21.8 °C in the northern-most eastern tributary, the Elk River (ET-1) (Table 8.3).

Average salinity varied from 0.63 ppt to 15.1 ppt for a range of 14.6 ppt from the northern to the southern-most main Bay segments (CB-1 to CB-5 respectively) (Table 8.3). Salinity differed considerably from year to year (Table 8.2), ranging over 6.4 ppt from the highest to lowest yearly Bay-wide average. These temporal and spatial salinity gradients are normal in estuarine systems.

The three measures of depth (water column depth, secchi disk depth, and WC-SD) are indices of light availability to the SAV. Table 8.2 reveals that during 1977 the Bay-wide average depth was lower than the other years. Bay-wide average depth, from year to year, depends upon locating the stations in the same place, and upon whether there has been a celestial or meteorological tidal import or export of water prior to sampling. It is unlikely that small differences in station position would influence the Bay-wide average water column depth. It therefore appears more likely that in 1977 tidal differences were exerting influence on the Bay-wide average water column depth.

Bay-wide average secchi disk depth was shallow in 1972 (Table 8.2), probably a result of turbidity induced by Tropical Storm Agnes which passed over the Chesapeake Bay area only a few months prior to sampling. In general, the secchi disk depth remained in the 71.0 to 79.6 cm secchi disk depth range throughout the 1970's (except in 1972 as mentioned above and in 1977 which was also a turbid year). The trend in the eighties indicates that the Bay's water may be becoming more turbid because the secchi disk depth in 1980 and 1981 is about 10 cm less than the secchi disk depth was during most of the 1970's. There also appears to be geographical trends in secchi disk depth (Table 8.3). The open Bay segments (CB) (except CB-2 where all the stations are located in small eastern tributaries and embayments); eastern embayments (EE); and eastern and western tributaries (ET, WT) that are south of 39°15' latitude (or about the latitude of Baltimore) have larger average secchi disk depth values than the Susquehanna Flats (CB-1), the more northern, eastern and western tributaries (ET-1 to ET-3, WT-1 to WT-3), and the upper reaches of the Patuxent River (TF-1, RET-1). This is due to freshwater inflows containing suspended sediments that have washed from upstream watershed areas.

TABLE 8.4a. THE PERCENTAGE AND NUMBER OF STATIONS WITH AND WITHOUT VEGETATION DURING 1971 TO 1981 MONITORING OF CHESAPEAKE BAY SAV

| Percent | Stations Per Year | |
|---|---|---|
| 100 | 624 | - The average number of stations visited per year. |
| 57 | 356 | - The total number of stations that never had SAV. |
| 43 | 268 | - The total number of stations that had SAV at least one year (624 minus 356). |

TABLE 8.4b. THE PERCENTAGE AND NUMBER OF VISITS TO STATIONS WITH AND WITHOUT VEGETATION DURING THE 1971 TO 1981 MONITORING OF CHESAPEAKE BAY SAV

| Percent | Total Visits | |
|---|---|---|
| 100 | 6,861 | - The total number of visits to stations during the 11 years of SAV sampling |
| 87 | 5,965 | - The total number of visits to stations that yielded no SAV in all three replications. |
| 13 | 896 | - Total number of visits that yielded SAV (6,861 minus 5,965). |

TABLE 8.5. A SUMMARY BY YEAR OF THE TOTAL SAV VOLUMETRIC DISPLACEMENT OR STANDING CROP AND THE AVERAGE NUMBER OF SPECIES OF ALGAE AND VASCULAR PLANTS MEASURED DURING THE MONITORING OF THE UPPER CHESAPEAKE BAY SAV

| Year | N | Mean Volumetric Displacement (cc/m$^2$) | Mean Number of Algae Species | Mean Number of Vascular Plant Species |
|---|---|---|---|---|
| 71 | 178 | 3.10 | 0.44 | 1.55 |
| | | (0.32) | (0.06) | (0.08) |
| 72 | 129 | 1.76 | 0.21 | 1.54 |
| | | (0.08) | (0.04) | (0.08) |
| 73 | 66 | 2.46 | 0.21 | 1.59 |
| | | (0.44) | (0.06) | (0.12) |
| 74 | 91 | 1.88 | 0.20 | 1.43 |
| | | (0.41) | (0.05) | (0.09) |
| 75 | 48 | 1.44 | 0.04 | 1.42 |
| | | (0.31) | (0.03) | (0.09) |
| 76 | 94 | 1.33 | 0.11 | 1.45 |
| | | (0.21) | (0.03) | (0.08) |
| 77 | 79 | 1.41 | 0.08 | 1.34 |
| | | (0.38) | (0.03) | (0.08) |
| 78 | 64 | 2.56 | 0.30 | 1.56 |
| | | (0.54) | (0.08) | (0.14) |
| 79 | 50 | 3.75 | 0.02 | 1.54 |
| | | (0.88) | (0.02) | (0.14) |
| 80 | 64 | 1.57 | 0.05 | 1.50 |
| | | (0.43) | (0.03) | (0.13) |
| 81 | 33 | 0.65 | 0.06 | 1.21 |
| | | (0.11) | (0.04) | (0.10) |
| Total | 896 | | | |

NOTES:

1. N refers to the number of visits to stations in the corresponding year that had vegetation.

2. The means reported for volumetric displacement have been calculated by first averaging the three replicates (the replicate average) from each station visit. The replicate averages are then averaged for all stations that had vegetation during the 1971 to 1981 sampling period. The numbers in parentheses are standard deviations of the average replicate average.

3. The mean number of species of algae and vascular plants was calculated by counting the total number of species in the three replicate samples (a species present in more than one replicate was only counted once). The number of species from the visits with vegetation were averaged by segment.

TABLE 8.6. A SUMMARY BY CBP SEGMENT OF TOTAL SAV VOLUMETRIC STANDING CROP AND AVERAGE NUMBER OF ALGAE AND VASCULAR PLANT SPECIES MEASURED DURING THE 1971 TO 1981 MONITORING OF THE CHESAPEAKE BAY SAV

| CBP Segment | N | Mean Volumetric Displacement (cc/m$^2$) | Mean Number of Algae Species | Mean Number of Vascular Plant Species |
|---|---|---|---|---|
| CB-1 | 32 | 3.67<br>(0.87) | 0.31<br>(0.06) | 1.81<br>(0.27) |
| CB-2 | 2 | 7.80<br>(7.62) | 0 | 1.5<br>(0.05) |
| CB-3 | 21 | 2.13<br>(0.82) | 0.38<br>(0.16) | 1.57<br>(0.22) |
| CB-4 | 2 | 0.36<br>(0.18) | 0 | 1.00<br>(0) |
| CB-5 | 68 | 1.58<br>(0.27) | 0.28<br>(0.07) | 1.15<br>(0.07) |
| EE-1 | 147 | 2.53<br>(0.43) | 0.14<br>(0.04) | 1.52<br>(0.07) |
| EE-2 | 150 | 1.17<br>(0.18) | 0.18<br>(0.04) | 1.25<br>(0.05) |
| EE-3 | 174 | 1.65<br>(0.22) | 0.22<br>(0.05) | 1.22<br>(0.04) |
| ET-1 | 1 | 0.18 | 0 | 1.0 |
| ET-2 | 1 | 0.72 | 0 | 1.0 |
| ET-3 | 5 | 0.79<br>(0.40) | 0 | 1.0<br>(0) |
| ET-4 | 111 | 2.59<br>(0.35) | 0.35<br>(0.06) | 2.16<br>(0.12) |
| ET-5 | 22 | 4.51<br>(1.18) | 0.09<br>(0.06) | 1.32<br>(0.14) |
| ET-6 | -- | -- | -- | -- |
| ET-7 | -- | -- | -- | -- |

(continued)

TABLE 8.6 (Continued)

| CBP Segment | N | Mean Volumetric Displacement (cc/$m^2$) | Mean Number of Algae Species | Mean Number of Vascular Plant Species |
|---|---|---|---|---|
| ET-8 | 18 | 2.48<br>(0.71) | 0.11<br>(0.11) | 1.61<br>(0.14) |
| ET-9 | 40 | 1.58<br>(0.36) | 0.08<br>(0.08) | 1.45<br>(0.09) |
| LE-1 | 8 | 0.38<br>(0.06) | 0.38<br>(0.08) | 0.88<br>(0.13) |
| RET-1 | 1 | 0.54 | 0.0 | 1.00 |
| WT-1 | -- | -- | -- | -- |
| WT-2 | 6 | 2.86<br>(1.74) | 0 | 1.33<br>(0.33) |
| WT-3 | 14 | 1.60<br>(0.63) | 0 | 1.43<br>(0.23) |
| WT-4 | -- | -- | -- | -- |
| WT-5 | 16 | 3.30<br>(1.12) | 0.19<br>(0.10) | 1.31<br>(0.15) |
| WT-6 | 19 | 2.30<br>(0.78) | 0.21<br>(0.12) | 1.90<br>(0.28) |
| WT-7 | 37 | 3.50<br>(0.92) | 0.22<br>(0.07) | 2.11<br>(0.21) |
| WT-8 | 1 | 0.18 | 0 | 1.0 |

NOTES:

1. N refers to the number of visits to stations in the corresponding segement that had vegetation.
2. The means reported for volumetric displacement have been calculated by first averaging the three replicates (the replicate average) from each station visit. The replicate averages are then averaged for all stations that had vegetation during the 1971 to 1981 sampling period. The numbers in parentheses are standard deviations of the average replicate average.
3. The mean number of species of algae and vascular plants was calculated by counting the total number of species in the three replicate samples (a species present in more than one replicate was only counted once). The number of species from the visits with vegetation were averaged by segment.
4. Dashes indicate that SAV was never encountered during the 1971 to 1981 period in the corresponding CBP segment.

TABLE 8.7. FREQUENCY OF OCCURRENCE OF EACH SAV SPECIES ENCOUNTERED DURING THE PERIOD FROM 1971 TO 1981 IN THE UPPER CHESAPEAKE BAY AND THE PERCENT OF TOTAL FREQUENCY

| Common Name | Scientific Name | Frequency | Percent |
|---|---|---|---|
| Widgeongrass | *Ruppia maritima* | 533 | 35.2 |
| Eelgrass | *Zostera marina* | 180 | 11.9 |
| Redhead-grass | *Potamogeton perfoliatus* | 174 | 11.5 |
| Sago pondweed | *P. pectinatus* | 102 | 6.7 |
| Eurasian watermilfoil | *Myriophyllum spicatum* | 90 | 6.0 |
| Horned pondweed | *Zanichellia palustris* | 78 | 5.2 |
| Common elodea | *Elodea canadensis* | 62 | 4.1 |
| Wild celery | *Vallisneria americana* | 55 | 3.6 |
| Naiad | *Najas guadalupensis* | 39 | 2.6 |
| Coontail | *Ceratophyllum demersum* | 5 | 0.3 |
| Curly pondweed | *P. cripus* | 4 | 0.3 |
| Slender pondweed | *P. pusillus* | 4 | 0.3 |
| Water-stargrass | *Heteranthera dubia* | 2 | 0.1 |
| Sea Lettuce | *Ulva sp.* | 54 | 3.6 |
| Unidentified algae, filamentous green | | 38 | 2.5 |
| | *Agardhiella sp.* | 33 | 2.2 |
| Muskgrass | *Chara sp.* | 20 | 1.3 |
| | *Ceramium* | 9 | 0.6 |
| | *Polysiphonia* | 8 | 0.5 |
| Unidentified algae, red | | 7 | 0.5 |
| Unidentified algae | | 4 | 0.3 |
| Unidentified algae, green | | 4 | 0.3 |
| | *Dasya sp.* | 2 | 0.1 |
| | *Enteromorpha spp.* | 2 | 0.1 |

NOTES:

1. The frequency was calculated by counting presence only once if a species was present in more than one replicate.

TABLE 8.8. FREQUENCY OF OCCURRENCE OF THE FIVE MOST FREQUENTLY OCCURRING SPECIES DURING EACH YEAR OF THE SAV SURVEY IN THE UPPER CHESAPEAKE BAY

| SAV Species | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Widgeongrass | 92 | 61 | 38 | 60 | 26 | 72 | 43 | 42 | 29 | 47 | 23 |
| Eelgrass | 65 | 45 | 7 | 15 | 17 | 7 | 14 | 5 | 1 | 1 | 3 |
| Redhead grass | 33 | 21 | 26 | 21 | 10 | 14 | 9 | 15 | 14 | 7 | 4 |
| Sago pondweed | 8 | 35 | 18 | 8 | 0 | 3 | 9 | 9 | 3 | 8 | 1 |
| Eurasian watermilfoil | 24 | 7 | 3 | 7 | 4 | 6 | 6 | 4 | 15 | 11 | 3 |

TABLE 8.9. FREQUENCY OF OCCURRENCE OF THE FIVE MOST FREQUENTLY OCCURRING SPECIES IN EACH CBP SEGMENT IN THE UPPER CHESAPEAKE BAY

| SAV Species | EE-1 | EE-2 | EE-3 | ET-1 | ET-2 | ET-3 | ET-4 | ET-5 | ET-6 | ET-7 | ET-8 | ET-9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Widgeongrass | 118 | 135 | 103 | 0 | 0 | 0 | 52 | 7 | - | - | 13 | 26 |
| Eelgrass | 8 | 7 | 96 | 0 | 0 | 0 | 0 | 0 | - | - | 14 | 28 |
| Redhead grass | 31 | 15 | 0 | 0 | 0 | 0 | 67 | 5 | - | - | 0 | 0 |
| Sago pondweed | 10 | 10 | 12 | 0 | 0 | 0 | 22 | 0 | - | - | 2 | 4 |
| Eurasian watermilfoil | 12 | 0 | 0 | 1 | 0 | 0 | 27 | 0 | - | - | 0 | 0 |

| SAV Species | CB-1 | CB-2 | CB-3 | CB-4 | CB-5 | WT-1 | WT-2 | WT-3 | WT-4 | WT-5 | WT-6 | WT-7 | WT-8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Widgeongrass | 0 | 0 | 6 | 1 | 37 | - | 0 | 1 | - | 0 | 5 | 24 | 1 |
| Eelgrass | 0 | 0 | 0 | 0 | 26 | - | 0 | 0 | - | 0 | 0 | 0 | 0 |
| Redhead grass | 0 | 0 | 10 | 0 | 0 | - | 1 | 1 | - | 7 | 10 | 27 | 0 |
| Sago pondweed | 0 | 0 | 7 | 0 | 13 | - | 0 | 0 | - | 1 | 7 | 12 | 0 |
| Eurasian watermilfoil | 24 | 2 | 3 | 0 | 0 | - | 5 | 0 | - | 0 | 3 | 2 | 0 |

TABLE 8.10. FREQUENCY OF OCCURRENCE OF THE FIVE MOST FREQUENTLY OCCURRING SPECIES IN INTERVALS OF WATER COLUMN DEPTH IN THE UPPER CHESAPEAKE BAY

| | Water Column Depth Intervals (m) | | | | | |
|---|---|---|---|---|---|---|
| SAV Species | 0 to 0.49 | 0.5 to 0.99 | 1.0 to 1.49 | 1.5 to 1.99 | 2.0 to 2.49 | 2.5 to 2.99 |
| Widgeongrass | 50<br>(3) | 301<br>(20) | 121<br>(8) | 54<br>(4) | 6<br>(<.1) | 1<br>(<.1) |
| Eelgrass | | 35<br>(2) | 50<br>(3) | 72<br>(50) | 17<br>(1) | 6<br>(<.1) |
| Redhead grass | 10<br>(1) | 107<br>(7) | 37<br>(3) | 20<br>(1) | 0 | 0 |
| Sago pondweed | 6<br>(<.1) | 58<br>(4) | 21<br>(1) | 15<br>(1) | 2<br>(<.1) | 0 |
| Eurasian watermilfoil | 3<br>(<.1) | 38<br>(3) | 35<br>(2) | 13<br>(1) | 1<br>(<.1) | 0 |

NOTE:

1. Percentages of the total frequency of occurrence (1,513) are enclosed in parentheses.

TABLE 8.11. THE NUMBER OF VISITS WITH AND WITHOUT VEGETATION BY WATER COLUMN DEPTH INTERVAL DURING THE 1971 to 1981 SAV MONITORING IN THE UPPER CHESAPEAKE BAY

| Water Column Depth Interval (m) | Number of Visits Without Vegetation | Number of Visits With Vegetation | Total Number # of Visits |
|---|---|---|---|
| 0 - 0.49 | 174 | 64 | 238 |
| 0.5 - 0.99 | 1,253 | 421 | 1,674 |
| 1.0 - 1.49 | 1,460 | 236 | 1,696 |
| 1.5 - 1.99 | 1,493 | 136 | 1,629 |
| 2.0 - 2.49 | 883 | 30 | 913 |
| 2.5 - 2.99 | 462 | 9 | 471 |
| 3.0 - 3.49 | 161 | 0 | 161 |
| 3.5 - 3.99 | 51 | 0 | 51 |

TABLE 8.12. FREQUENCY OF OCCURRENCE OF THE FIVE MOST FREQUENTLY OCCURRING SPECIES IN INTERVALS OF SECCHI DISK DEPTH

| | Secchi Disk Depth Interval (cm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SAV Species | 0-19.9 | 20-39.9 | 40-59.9 | 60-79.9 | 80-99.9 | 100-119.9 | 120-139.9 | 140-159.9 | 160-179.9 | 200-219.9 |
| Widgeongrass | 5<br>(<.1) | 40<br>(3) | 110<br>(7) | 164<br>(11) | 99<br>(7) | 16<br>(1) | 6<br>(<.1) | 1<br>(<.1) | 0 | 0 |
| Eelgrass | 2<br>(<.1) | 1<br>(<.1) | 12<br>(1) | 42<br>(3) | 29<br>(2) | 17<br>(1) | 10<br>(1) | 1<br>(<.1) | 1<br>(<.1) | 0 |
| Redhead grass | 11<br>(1) | 8<br>(1) | 18<br>(1) | 64<br>(4) | 32<br>(2) | 0 | 7<br>(1) | 1<br>(<.1) | 0 | 0 |
| Sago pondweed | 1<br>(<.1) | 3<br>(<.1) | 12<br>(1) | 48<br>(3) | 22<br>(2) | 4<br>(<.1) | 3<br>(<.1) | 0 | 0 | 1<br>(<.1) |
| Eurasian watermilfoil | 3<br>(<.1) | 9<br>(1) | 12<br>(1) | 15<br>(1) | 16<br>(1) | 1<br>(<.1) | 8<br>(1) | 0 | 0 | 0 |

NOTES:

1. Percentages of the total frequency of occurrence (1,513) are enclosed in parentheses.

TABLE 8.13. THE NUMBER OF VISITS WITH AND WITHOUT VEGETATION BY WATER COLUMN DEPTH INTERVAL DURING THE 1971 TO 1981 SAV MONITORING IN THE UPPER CHESAPEAKE BAY

| Secchi Disk Depth Interval (cm) | Number of Visits Without Vegetation | Number of Visits With Vegetation | Total Number of Visits |
|---|---|---|---|
| 0 - 19.9 | 72 | 16 | 88 |
| 20.0 - 39.9 | 591 | 57 | 648 |
| 40.0 - 59.9 | 1,286 | 152 | 1,438 |
| 60.0 - 79.9 | 1,758 | 269 | 2,027 |
| 80.0 - 99.9 | 1,016 | 154 | 1,170 |
| 100.0 - 119.9 | 349 | 35 | 384 |
| 120.0 - 139.9 | 200 | 27 | 227 |
| 140.0 - 159.9 | 64 | 2 | 66 |
| 160.0 - 179.9 | 23 | 1 | 24 |
| 180.0 - 199.9 | 19 | 1 | 20 |
| 200.0 - 219.9 | 15 | 2 | 17 |
| 220.0 - 239.9 | 6 | 0 | 6 |
| 240.0 - 259.9 | 3 | 0 | 3 |

TABLE 8.14. FREQUENCY OF OCCURRENCE OF THE FIVE MOST FREQUENTLY OCCURRING SPECIES IN 19.9 cm INTERVALS OF WC-SD DEPTH IN THE UPPER CHESAPEAKE BAY

|  | WC-SD Intervals (cm) |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAV Species | 0-19.9 | 20-39.9 | 40-59.9 | 60-79.9 | 80-99.9 | 100-119.9 | 120-139.9 | 140-159.9 | 160-179.9 | 180-199.9 | 200-339.9 |
| Widgeongrass | 252<br>(17) | 86<br>(6) | 46<br>(3) | 25<br>(2) | 15<br>(1) | 5<br>(<.1) | 5<br>(<.1) | 4<br>(<.1) | 2<br>(<.1) | 1 | 0 |
| Eelgrass | 33<br>(2) | 17<br>(1) | 15<br>(1) | 14<br>(1) | 13<br>(1) | 8<br>(1) | 6<br>(<.1) | 7<br>(1) | 1<br>(<.1) | 1 | 0 |
| Redhead grass | 84<br>(6) | 24<br>(2) | 9<br>(1) | 9<br>(1) | 6<br>(<.1) | 5<br>(<.1) | 1<br>(<.1) | 2<br>(<.1) | 0 | 1 | 0 |
| Sago pondweed | 56<br>(4) | 8<br>(1) | 15<br>(1) | 5<br>(<.1) | 6<br>(<.1) | 3<br>(<.1) | 0 | 1<br>(<.1) | 0 | 0 | 0 |
| Eurasian watermilfoil | 26<br>(2) | 12<br>(1) | 13<br>(1) | 7<br>(1) | 2<br>(<.1) | 1<br>(<.1) | 1<br>(<.1) | 1<br>(<.1) | 0 | 1 | 0 |

NOTE:

1. Percentage of the total frequency of occurrence (1,513) are enclosed in parentheses.

TABLE 8.15. THE NUMBER OF VISITS WITH AND WITHOUT VEGETATION BY WC-SD DEPTH INTERVAL DURING THE 1971 TO 1981 SAV MONITORING IN THE UPPER CHESAPEAKE BAY

| WC-SD Interval (m) | Number of Visits Without Vegetation | Number of Visits With Vegetation | Total Number of Visits |
|---|---|---|---|
| 0 - 19.9 | 827 | 361 | 1,188 |
| 20.0 - 39.9 | 691 | 130 | 821 |
| 40.0 - 59.9 | 651 | 88 | 739 |
| 60.0 - 79.9 | 688 | 51 | 739 |
| 80.0 - 99.9 | 519 | 36 | 555 |
| 100.0 - 119.9 | 429 | 18 | 447 |
| 120.0 - 139.9 | 480 | 11 | 491 |
| 140.0 - 159.9 | 297 | 14 | 311 |
| 160.0 - 179.9 | 302 | 2 | 304 |
| 180.0 - 199.9 | 229 | 5 | 234 |
| 200.0 - 219.9 | 106 | 0 | 106 |
| 220.0 - 239.9 | 79 | 0 | 79 |
| 240.0 - 259.9 | 52 | 0 | 52 |
| 260.0 - 279.9 | 23 | 0 | 23 |
| 280.0 - 299.9 | 21 | 0 | 21 |
| 300.0 - 319.9 | 6 | 0 | 6 |
| 320.0 - 339.9 | 2 | 0 | 2 |

If the secchi disk depth is subtracted from water column depth, the derived variable, WC-SD, is a measure of the depth zone that has less light than in the surface water layer. WC-SD is an index of the distance that SAV must penetrate or grow through to reach the greater amounts of light in the surface water layer. Prior to 1977 there were no distinct trends in WC-SD, except that WC-SD was large in 1972 and 1973 possibly due to Tropical Storm Agnes; the low WC-SD value in 1977 is probably due to the shallow total depth that year (Table 8.2). There is a suggestion (Table 8.2) that WC-SD began to increase after 1977, since beginning in 1977 there was an increase in WC-SD every year through 1981. Examination of WC-SD by segment identifies some geographical trends that are not observed when water column depth and secchi disk depth are considered individually (Table 8.3). Two examples are presented that demonstrate the insights provided by examining WC-SD. The three northern-most eastern tributaries, the Elk, Bohemia and Sassafras Rivers (ET-1, ET-2, ET-3 respectively all have shallow secchi disk depths; ET-2 has the least light penetration, with a secchi disk depth of 36.2 cm, yet the depth of water SAV must penetrate, as estimated by WC-SD, is greatest in ET-1 (1.39 cm) and least in ET-3 (0.86 cm). Another example involves the interaction of water column depth and secchi disk depth between the Choptank and the Nanticoke Rivers (ET-5 and ET-6 respectively). The Nanticoke River has a deeper water column and more turbid water than the Choptank. This results in a WC-SD depth difference between ET-5 and ET-6 of 36 cm, a much greater difference than is evident when secchi disk depth or water column depth are considered independently.

## Submerged Aquatic Vegetation Trends

When SAV abundance is measured as the percent of stations with with vegetation, Chesapeake Bay SAV has been sparsely distributed since the beginning of SAV sampling in 1971. Table 8.4a indicates that 57% of the stations visited each year never yielded SAV. Table 8.4b indicates only 896 visits, or 13% of the total 6861 visits to stations, yielded SAV in at least one of the three replicates. One visit represents a single year's sampling at a single station. The majority of the SAV community analysis in this report relies upon the 896 visits where SAV was found. Moreover, the number of visits yielding vegetation has decreased during the eleven years of sampling, most drastically the year after Tropical Storm Agnes (1972 to 1973) (Table 8.5). After the post-Agnes 1972 to 1973 decline and prior to the 1980 to 1981 drop in the number of stations with SAV, there was no definitive change in in the number of stations with SAV. Most of the stations void of SAV in 1980, never recovered to a pre-Agnes condition. Another way of examining this is that by 1974, or after four years of sampling, over half (464) of the 896 visits with vegetation had been completed. The number of visits by year (Table 8.5) and by segment (Table 8.6) that yielded SAV are large scale, geographical measures of SAV extent.

SAV volumetric displacement is a measure of standing crop. Volumetric displacement is a measure of SAV density within 1 $m^2$ areas. Table 8.5

suggests that volumetric displacement has changed only slightly over the study period, and that no trends of increase or decrease are obvious. A survey of research reports by Stevenson and Confer (1978) indicates that in Chesapeake Bay the leaf standing crop of Zostera marnia ranges 6 to 597 g dry weight/m$^2$. The volumetric displacement measured in this monitoring program can be compared to the g dry weight/m2 measure by assuming that SAV has a density approximately equal to water, or about 1 g/cc. This assumption is reasonable because dead SAV can be observed on the water's surface, neutrally bouyant, or in mats of detritus on the bottom. Therefore, a SAV density of, at most, 1 g/cc is reasonable and can be used as a conversion factor to convert volumetric displacement measured in cc/m$^2$ to another unit of standing crop measured as g dry weight/m$^2$. After conversion of the volumetric displacements reported in this monitoring program to g dry weight/m2, one can see that the standing crops measured during this monitoring program appear low. This is because the studies surveyed by Stevenson and Confer (1978) concentrated their spatial coverage on specific areas known for high SAV density. The 1981 volumetric displacement is the lowest annual average encountered, and could be the beginning of a trend of small scale thinning of SAV beds. Table 8.5 indicates that the number of vascular plant or algae species has not changed over time.

Table 8.6 presents the number of visits and vegetation by segment. (A visit represents one year's sampling at a single station). There are 4 segments that have been void of vegetation since the beginning of sampling in 1971: ET-6, ET-7, WT-1 and WT-4. Eight other segments had six or less visits that yielded SAV: CB-2, CB-4, ET-1, ET-2, ET-3, RET-1, WT-2 and WT-8. The large eastern drainages, CB-3 to ET-4, EE-1, EE-2 to ET-5, EE-3 to CB-5 and two eastern tributaries in the southern end of the study area, ET-8 and ET-9, had more visits with SAV than most other areas. It is difficult to explain why ET-6 and ET-7, located in the middle of the large eastern drainage grouping with the most occurrences of SAV, never had vegetation during the 11 years of sampling. There are few trends in volumetric displacement or species diversity across geographical areas (Table 8.6). One observation is that segments (except CB-2) with less than 10 visits revealing vegetation had the lowest volumetric displacement. This suggests that there are segments that have never had many visits with SAV (a large scale measure of SAV quality) and that when SAV is found in these segments that have had few visits with SAV, the SAV is thin and sparse as indicated by the volumetric displacement (a small scale measuare of SAV quality). Species diversity trends are generally difficult to interpret and do not appear to be informative. Table 8.6 does suggest that, in the segments with larger numbers of visits yielding SAV, the mean diversity of vascular SAV was larger. This is expected since with more visits yielding SAV, samples with rare species are more likely. It also may indicate that, as has been suggested by community ecologists, species diversity is positively related to community stability.

The SAV community in this data base consists of 13 species of vascular SAV and 7 species of algal SAV (there are other vegetation categories of unidentified species). Species frequency of occurrence ranked by their frequency of occurrence are presented in Table 8.7. The frequency of occurrence of the five most frequently occurring species (widgeongrass, eelgrass, redhead grass, sago pondweed and eurasian watermilfoil) are examined in terms of their frequency of occurrence by year (Table 8.8), CBP segment (Table 8.9), intervals of water column depth (Table 8.10), intervals of secchi disk depth (Table 8.12), and intervals of WC-SD.

Table 8.8 indicates that sago pondweed was the only species not declining during the 1971 to 1981 monitoring period; it appears that sago pondweed increased to its highest frequency of occurence in 1972, the year of Tropical Storm Agnes. Widgeongrass was the most frequently occurring SAV species in all years and decreased as a percentage less than any of the other four most frequently occurring species. There is a suggestion that, from 1976 through 1978, SAV frequency of occurrence stablilized.

Table 8.9 contains the frequency of occurrence of the 5 most frequently occurring species by CBP segment. Many of the geographical trends described in Table 8.6 are further understood after examining Table 8.9. The salinity tolerances of the species are suggested by their geographic distribution. Eurasian watermilfoil resides in the fresher northern Bay and is the primary species inhabiting the Susquehanna Flats. On the other extreme, eelgrass is the most salt-tolerant species of the five most abundant species and resides in the southern reaches of the study area. The other three species appear more widely tolerant. Widgeongrass dominates the eastern embayments (EE-1, EE-2, and EE-3) and was found in most of the samples that have SAV. The eastern embayments have contributions from all of the five most frequently occurring species.

Table 8.10 contains the frequency of occurrence of the five most frequently occurring species by water column depth interval. There were only a few occurrences of SAV below 2 m, but there were 1,596 or 23 percent of the visits to stations, with a depth below 2 m (Table 8.11). Four of the SAV species occurred most frequently in the 0.5 to 0.99 m water column depth interval; eelgrass seems to occur at deeper water column depths, occurring most frequently in the 1.5 to 1.99 m water column depth interval. This could be related to the aforementioned higher salinity tolerance of eelgrass The 0.5 to 0.99 m water column depth interval had the most visits yielding one of the five most frequently occurring species (Table 8.10). Examination of Table 8.11 shows that the 0 to 0.49 m water column depth interval had the highest yield of SAV when expressed as a percent of visits with SAV; 64 visits, or 27 percent yielded vegetation. In the 0.5 to 0.99 m depth interval 421 visits, or 25 percent, yielded vegetation. There were only 238 visits to the 0 to 0.49 m water column depth interval. In the next deepest water column depth interval (0.5 to 0.99 m) there were 1674 visits; this is 86 percent more visits than in the 0 to 0.49 m water column depth interval. If the 0 to 0.49 m water column depth interval had been sampled as much as the 0.5 to 0.99 m water column depth interval, and the SAV yield remained at 27 percent there would have been about 452 visits with SAV, which is over half the total number of successful SAV visits in the entire water column. (Table 8.11).

Table 8.12 is a presentation of the frequency of occurrence of the five most frequently occurring species by secchi disk depth interval. All five species appeared to occur infrequently in turbid water in the interval from 0 to 39.9 cm of secchi disk depth. If the number of visits with vegetation secchi disk depth interval are considered, widgeongrass and redhead grass appear to be more tolerant than the other three species. In the 0 to 19.9 secchi disk depth interval, of the 16 visits to stations with vegetation (Table 8.13), redhead grass was found in 11 visits (Table 8.12) and in the 20.0 to 39.9 cm secchi disk depth interval, of the 57 visits to stations with vegetation (Table 8.13), widgeongrass was found in 40 of them (Table 8.12). The apparent greater tolerance of these two species to turbidity may explain why widgeongrass was always the most frequently occurring species and why redhead grass occurrence was the most constant during the 1971 to 1981 SAV monitoring period (Table 8.8). In contrast, eelgrass, was one of the five most frequently occurring species, the most frequently occurring when the secchi disk depth was greater than 100 cm and least frequently occurring when the secchi disk depth was less than 60 cm. This suggests that ell-grass may be less tolerant to turbidity than the other SAV species.

Table 8.14 contains the frequency of occurrence of the five most frequently occurring species by WC-SD intervals. When the distance from the secchi disk to the water bottom exceeded 99.9 cm, the frequency of occurrence of the five most frequently occurring species decreased markedly. This is also evident in Table 8.15, which demonstrates that the total number of visits with SAV and the percent of total visits with SAV decrease rapidly when the WC-SD depth exceeded 99.9 cm. When WC-SD depth exceeded 159.9 cm, little SAV was found (Table 8.15). This sharp interruption of SAV distribution suggests that the SAV are intolerant of reduced light whether it is because of a shallow secchi disk depth or a deep water column depth.

## RECOMMENDATIONS

The recommendations presented below are based on a preliminary and descriptive analysis of SAV data collected by the MDNR and USFWS in the Maryland portion of the upper Chesapeake Bay. The recommendations are based only upon findings suggested by the 1971-1981 SAV data base. The descriptions, monitoring, and management recommendations are based only on information from Maryland's upper Chesapeake Bay and the years 1971-1981. The data were not collected to address all of the issues related to SAV (e.g., nutrient enrichment or herbicide effects).

### Monitoring

1. Any sampling plan designed for use in the future should maintain geographic, temporal, and methodological consistency with the previous years of sampling, in order to compare current with historical data.

2. Continued monitoring of those stations in CBP segments which have not yielded SAV (ET-6, ET-7, WT-1 and WT-4) or have yielded little SAV (CB-2, CB-4, ET-1, ET-2, ET-3, RET-1, WT-2 and WT-8) since 1971 should be reduced and limited until aerial imagery or exploratory sampling indicates that there has been re-establishment of SAV.

3. The most shallow depth interval (0 to 0.5 m) should be sampled more frequently. The 0 to 0.5 m interval had the greatest percentage of stations with vegetation (27 percent), but was only visited on 3 percent of the total visits. In effect, increased sampling of the 0 to 0.5 m depth would involve the establishment of stations in the upstream and backwater reaches of tributaries. Generally there are too many SAV stations in the open bay area and too few in the shallow areas.

4. Volumetric displacement appears to be a measure of limited value if the primary purpose of the SAV monitoring is to detect large scale changes in SAV distribution. The Bay-wide average volumetric displacement, a measure of small scale SAV density, has changed little over the eleven years of sampling. The variation as measured by the pooled within-station variation, or variation among replicates at a station, is 39.4 percent, which is much too large. Volumetric displacement is a measure of small scale changes in SAV density (e.g., standing crop), and to be done correctly and to minimize the variation among replicates, optimal quadrat sizes and sample numbers should be determined for each location. Volumetric displacement determination is also the most time consuming measure. Continued volumetric displacement sampling should be limited. The elimination of deep water stations (greater than 2 m) and the elimination of volumetric displacement measurement would more than allow for more complete coverage of the 0 to 0.5 m depth areas and occassional exploratory sampling.

## Management

1. The information described in this report and the continued collection of similar data is extremely important for providing guidance to those involved with the management of Chesapeake Bay, especially when information is needed regarding SAV in a specific location in the upper Chesapeake Bay.

2. Visits to stations in the eastern embayments yielded SAV much more often than in any other areas. The especially high frequency of SAV occurrence should be considered when impact to Chesapeake Bay's upper eastern shore is being evaluated. For example, the consideration and evaluation of proposals to dredge and fill, modify hydrology to increase saltwater intrusion, or change upstream agricultural practices, should involve knowledge of the higher quality of the SAV in the eastern embayments. In contrast, it should also be known that a number of areas that had SAV, now have limited or no SAV populations. All the segments in the northern-most part of the Bay (except Middle River) have extremely limited SAV populations: the Susquehana Flats, the Elk, Bohemia, Chester, Gunpowder, Back and Bush Rivers. Three

western tributaries also have sparse SAV populations: the Patuxent, West and South Rivers.

3. The Nanticoke and Wicomico Rivers have been void of SAV since 1971, but they are bounded to the north, south, and west by areas that have the highest frequency of SAV occurrence in the upper Chesapeake Bay. Answers as to why these drainages have no SAV could provide information regarding the factors controlling SAV distribution and the management of SAV exposed to similar declines. SAV transplantation, nutrient enrichment, and caging studies in this area would be of great value.

4. Increased suspended load, or turbidity, and freshwater inflow appear to be related temporally and spatially to decreased SAV presence, especially to the SAV declines that occurred in the early seventies. Management schemes that reduce upstream nutrient and sediment sources may allow re-establishment of historical SAV beds. Eelgrass seems to be most sensitive to turbidity, and widgeongrass and redhead grass are the least sensitive to turbidity.

# APPENDIX G

# EXISTING INTERSTATE INSTITUTUTIONAL ARRANGEMENTS

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SECTION 1

## INTRODUCTION

Eight interstate institutions are responsible for some aspect of government activity related to the resources and quality of Chesapeake Bay. No single interstate institution deals with the full geographic extent of the 64,000 square mile Chesapeake Bay drainage system, although several deal with a full range of important management issues for the Chesapeake Bay area.

Each interstate institution is a unique entity with membership and staff drawn from a limited population of state agencies, state legislatures, research institutions, and Federal agencies. Membership is highly overlapping. The interests of a single agency are often represented on several of the eight interstate committees or commissions. Each interstate group is composed of those agencies that can contribute to resolving a specific issue or problem the group was chartered to address. Together, they form a regulatory and administrative network with the potential for coordinating interstate action on virtually all Chesapeake Bay resource management issues that may arise.

The need for interstate coordination in the Potomac River was recognized many years ago and resulted in the adoption of the Potomac Valley Conservancy District Commission in 1940 and the Potomac River Company in 1958. The Atlantic States Marine Fisheries Compact was established in 1942. Formal mechanisms for interstate coordination of activities affecting the Chesapeake Bay itself were only recently established. Research institutions studying the Bay from an ecological, rather than jurisdictional perspective, formed the Chesapeake Research Consortium in 1970. The other Bay-wide institutions, including the Bi-State Working Committee, the Chesapeake Bay Commission, and the Chesapeake Bay Research Board, were not authorized until after 1970. (The Bi-State Committee was organized in the fall of 1970; the Chesapeake Bay Commission was organized in 1981; and the Research Board has not yet been constituted.) These groups do not have a long, cooperative institutional history. Nonetheless, they represent a significant potential for improved management of the Chesapeake Bay resources. This appendix discusses each institution -- its founding instrument, the geographic scope, the purposes, powers, duties, the membership, the resources, and the activities.

## SECTION 2

# THE CHESAPEAKE BAY COMMISSION

## INTRODUCTION

The Chesapeake Bay Commission was created in 1980 by joint action of the Maryland and Virginia General Assemblies (NR Article, Sec. 8-302, Annotated Code of Maryland; Title 62.1, Section 62.1-69.5 to 62.1-69.20, Code of Virginia). The Acts creating the Commission recognized Chesapeake Bay and its tributaries, wetlands, and dependent natural resources as an integrated ecosystem shared by the two states. The substantial joint interest of the two states in the use of resources includes management and regulatory programs, implementation methods, and actions affecting migratory fowl, finfish, shellfish, commercial and mercantile uses, and water quality.

## GEOGRAPHIC SCOPE

The Bay is defined to include tributaries (extent not specified), wetlands, and dependent natural resources shared by Maryland and Virginia. The upper Potomac, most of the Susquehanna River, and other tributaries extending into Delaware are not included in the definition of the Bay. The authorizing statement (". . . all actions which affect water quality substantively involve the joint interests of the state and the commonwealth . . .") implies that the Commission should take an active interest in up-stream activities to the extent that they affect water quality.

## PURPOSES OF THE COMMISSION

The Commission is given a broad mandate to examine all aspects of governance of the Bay and its resources. Its purposes are to:

- assist the legislatures of Maryland and Virginia in responding to problems of mutual concern related to Chesapeake Bay;
- promote inter-governmental cooperation;
- encourage cooperative, coordinated resource planning and action;
- provide, where appropriate, for uniformity in application of legislation; and
- recommend improvements in the existing management system for the benefit of the present and future inhabitants of the Chesapeake Bay region.

## DUTIES OF THE COMMISSION

The Commission is directed to carry out the following activities:

- identify specific Bay management concerns requiring inter-governmental coordination and cooperation;

- recommend to the states, and Federal and local governments legislative and administrative actions necessary to effectuate coordinated and gainful employment and maintenance of a high-quality environment;
- respect and support the primary role of the signatory states and their respective administrative agencies in managing the region's resources;
- collect, analyze, and disseminate information on the region for the General Assemblies;
- represent the common interest of the signatories as they are affected by activities of the Federal government; and
- provide an arbitration forum to serve as an advisory mediator for bi-state programmatic conflicts when requested by the legislatures or the Executive branches of both states.

## POWERS OF THE COMMISSION

In carrying out its role, the Commission may:

- collect, compile, analyze, interpret, coordinate, tabulate, summarize, and distribute technical and other data,
- contract for or conduct studies (but not for primary scientific research);
- prepare and disseminate information;
- serve as an advisory board to any requesting agency of either state on matters of bi-state concern;
- apply for grants, services, etc.;
- purchase administrative supplies; and
- hire staff.

## TIME PERIOD OF AUTHORIZATION

The Commission is authorized for ten years, after which time it may be extended for additional ten-year periods. The Commission may be dissolved if a signatory state withdraws by act of its General Assembly.

## MEMBERSHIP AND VOTING

Seven members are appointed to the Commission from each state. Each state's delegation includes two senators, three delegates, a citizen member, and the Governor or his designee. Actions taken by the Commission require the affirmative vote of a simple majority of those present; four members from each state constitute a quorum.

Current members of the Commission include:

| | |
|---|---|
| Honorable Elmo G. Cross, Jr. | Senate of Virginia |
| Honorable Joseph V. Gartlan, Jr. (Current Chairman) | Senate of Virginia |
| Honorable Robert S. Bloxom | Virginia House of Delegates |
| Honorable Theodore V. Morrison, Jr. | Virginia House of Delegates |
| Honorable W. Tayloe Murphy | Virginia House of Delegates |
| Honorable Betty J. Diener | Virginia Governor's Designee |
| Mr. Irvine B. Hill | Virginia Citizen |
| Honorable Joseph J. Long, Sr. (Current Vice-Chairman) | Senate of Maryland |
| Honorable Gerald W. Weingrad | Senate of Maryland |
| Honorable Elizabeth S. Smith | Maryland House of Delegates |
| Honorable W. Henry Thomas | Maryland House of Delegates |
| Honorable Torrey C. Brown | Maryland Governor's Designee |
| Honorable James E. McClellan | Maryland House of Delegates |
| Honorable Thomas A. Reymer | Maryland House of Delegates |
| Honorable Michael H. Weir | Maryland House of Delegates |
| Mr. Jack Witten | Maryland Citizen |

## BUDGET AND STAFF

Maryland and Virginia are currently providing 75,000 dollars per annum for a total Commission appropriation of 150,000 dollars. The Commission has a staff of three, headed by an Executive Director, at its office in Annapolis, Maryland.

## ACTIVITIES OF THE COMMISSION

The Commission's activities center on analyzing the policies which govern the management, planning, and regulation of resource use in Chesapeake Bay, and on making recommendations for improvements through legislative or administrative actions. The Commission has established an interest in organizational and substantive management policies, coordinative research, and a cooperative liaison with the various interest groups and government institutions involved in governing the Chesapeake Bay region. It has provided for participation of non-member individuals through a task force.

The Commission has set goals and priorities to define a long-range action agenda. The Commission's first priority for fiscal year (FY) 1982 is to enhance a coordinated Bay-wide approach to fisheries management through dealing with the immediate situation created by court action on residency requirements, beginning to examine the prospects for Bay-wide management of important fish species, and examining the problems of maintenance and enhancement of environmental conditions necessary for continued viability of important fisheries. The need for (or lack of) reciprocal licensing; enforcement problems, and the potential for increased crab harvesting pressure which may result from an on-going court challenge to Maryland and Virginia residency requirements, are issues receiving Commission consideration.

The Commission has also determined that helping Maryland and Virginia capitalize on the results of the Chesapeake Bay Program is an important priority for FY 1982. Management policies emanating from the Program which the Commission will review include (a) how new information on nutrient enrichment, toxic substances, and submerged aquatic vegetation is used in on-going planning, management, and regulatory programs, (b) how the states can best continue to monitor the condition of the Bay and manage the data, (c) what refinements to existing programs appear to be desirable as a result of new information developed, and (d) what institutional arrangements are recommended.

Finally, the Commission is seeking to achieve the confidence of the Federal government, local governments, and citizens in the two states and encourage the states to accept responsibility for goverance and stewardship of Chesapeake Bay. The Commission is initiating a formal liaison with interstate institutions, Federal and local agencies, and citizens and trade groups.

SECTION 3

# THE BI-STATE WORKING COMMITTEE FOR CHESAPEAKE BAY AND COASTAL AREAS OF MARYLAND AND VIRGINIA

## INTRODUCTION

The Bi-State Working Committee was established by an Agreement between the Governors of Maryland and Virginia on August 27, 1979. The Agreement recognizes (1) that Chesapeake Bay is one of the most productive estuaries in the world, (2) that the Bay and coastal areas are essential to the national interest for commerce, navigation, defense, and the economic well-being of the states, and (3) that a common mutual concern exists regarding dredging and placement of: dredged material; maritime development; water quality; prevention and clean-up of spills of hazardous substances; shoreline erosion; protection of living marine resources and fisheries management; permitting of minor shoreline alterations; flood-plain management; protection of waterfowl and wildlife habitat; protection of wetlands, beaches, and dunes; sedimentation of tidal water; and continuous coordination of research, planning, advisory, permitting, and management activities in the two states.

## GEOGRAPHIC SCOPE

Chesapeake Bay and coastal areas of Maryland and Virginia are not defined in the agreement. In the briefing document which accompanied the agreement, however, the area of interest is defined to include all of the tidewater counties of both states. Non-tidal portions of the drainage basin are not included in the definition, but nothing in the agreement precludes the involvement of the Committee in up-stream activities.

## PURPOSES OF THE AGREEMENT

The Governors of Virginia and Maryland agreed:

o to coordinate the research, planning, advisory, permitting, and management programs of agencies of both states which affect coastal and Bay resources and activities, and to effect such coordination; and

o to direct the Secretary of Commerce and Resources for the Commonwealth of Virginia and the Secretary of Natural Resources for the State of Maryland to organize and co-chair a Bi-State Working Committee of agency representatives from both states.

## RESPONSIBILITIES OF THE COMMITTEE

The Bi-State Working Committee was given the following responsibilities:

o assess coastal and Bay issues such as dredging and placement of dredge material; maritime development; water quality; prevention and clean-up of spills of hazardous substances; shoreline erosion; protection of living marine resources and fisheries management, permitting of minor shoreline alterations; flood-plain management, protection of waterfowl and other wildlife habitat; protection of wetlands, beaches, and dunes; and sedimentation of tidal waters;

- establish mutually compatible goals, objectives, and policies guiding the conduct of the programs mentioned;
- exchange information of all coastal and Bay matters of mutual interest;
- discuss problems associated with the operational activities of permitting and management agencies, and determine effective Bi-State solutions,
- analyze recommendations for a Bi-State approach to Federal coastal and Bay initiatives, including proposed legislation and regulations, studies, planning programs, permitting decisions, and management activities;
- respond to recommendations for alternative institutional methods of coordinating programs with each other and with the Federal government;
- interact frequently with Federal and local officials, private sector representatives, members of citizen's groups, and the scientific community; and
- prepare an annual report on the major coastal and Bay issues of mutual concern and recommended Bi-State action.

## POWERS OF THE COMMITTEE

The Committee is purely advisory and coordinative. It was not given any management or regulatory authority. The Committee may:

- make recommendations to the Governors, participating agencies, and other groups; and
- encourage the joint exercise of management or regulatory authority vested in participating agencies.

## TERM OF AUTHORIZATION

No term is specified in the agreement; however, because it is gubernatorially authorized, official confirmation of an intent to continue any time a new Governor is elected by either state is practiced. Governor Charles Robb has announced his intent to have Virginia continue to pursue the terms of the agreement.

## MEMBERSHIP AND VOTING

The Committee consists of seven members from each state. Members are the heads of the principle agencies in both states concerned with the Bay and coastal areas; each member may appoint an alternate. The Committee operates by consensus only and has not developed any voting protocol. Current members of the Committee are:

| Maryland | Virginia |
|---|---|
| Honorable Torrey C. Brown<br>Secretary of Natural Resources | Honorable Betty J. Diener<br>Secretary of Commerce and Resources |
| Mr. Gregory Halpin<br>Port Administrator<br>Maryland Port Administration | Mr. J. Robert Bray<br>Executive Director<br>Virginia Port Authority |
| Mr. William Eichbaum<br>Environmental Health Administration<br>Maryland Department of Health and Mental Hygiene | Mr. Richard N. Burton<br>Acting Executive Director<br>State Water Control Board |
| Honorable James O. Roberson<br>Secretary of Economic and Community Development | Mr. William Pruitt<br>Commissioner<br>Marine Resources Commission |
| Dr. Ian Morris<br>Director, University of Maryland Center for Environmental and Estuarine Studies | Dr. Frank Perkins<br>Director<br>Virginia Institute of Marine Science |
| Honorable Wayne Cawley<br>Secretary of Agriculture | Dr. James B. Kenley<br>Commissioner<br>Department of Health |
| Honorable Constance Lieder<br>Secretary of State Planning | Ms. Sheila Prindiville<br>Administrator<br>Council on the Environment |

## BUDGET AND STAFFING

The Committee does not have an authorized budget. Meeting expenses are minor and are covered by the budgets of the Maryland Department of Natural Resources and the Virginia Office of Commerce and Resources. The co-chairmen specify assignments to staff the Committee directly from existing agency personnel; staff is provided in Maryland through the Tidewater Administration and in Virginia through the Council on the Environment. Committee members assign staff from their agencies to individual projects as appropriate.

## ACTIVITIES OF THE COMMITTEE

The Committee's activities fall into three categories: (1) evaluation of on-going programs to determine if closer coordination is feasible, (2) development of agreements between parallel agencies from both states on particular procedures, and (3) joint evaluation of Federal activities. Some of the particular activities in which the Committee is involved include:

- developing bi-state agreements on notification procedures for major water withdrawals and air emissions near state boundaries;

- investigating potential future funding and utilization of the Corps of Engineers Chesapeake Bay Hydraulic Model;
- reviewing the feasibility of oyster shucking machinery under development and determining the advisability of future development funding;
- evaluating the two states' emergency response and prevention programs and the need for additional bi-state program coordination;
- developing joint proposals for striped bass research funding; and
- making recommendations to the Governors concerning appointments to the Chesapeake Bay Research Board.

## SECTION 4

# THE CHESAPEAKE RESEARCH CONSORTIUM

## INTRODUCTION

The Chesapeake Research Consortium (CRC) was incorporated in 1972 as an association of four institutions -- The Johns Hopkins University, the University of Maryland, the Smithsonian Institution, and the Virginia Institute of Marine Science -- each of which has long-standing involvement in research on problems affecting the Bay.

## PURPOSES OF THE CONSORTIUM

The Consortium was created to coordinate the scientific staff and facilities of the member institutions to achieve a broad-based, Bay-wide approach to the complex investigations which are essential to wise management of the resources of the Chesapeake Bay.

## FUNCTIONS OF THE CONSORTIUM

The Consortium provides the following services:

- assembles multi-disciplinary teams to investigate problems;
- provides scientists, laboratories, technicians, computer capabilities, and research vessels on a scale large enough to attack complex Bay-wide problems;
- assists management agencies;
- conducts workshops and symposium;
- contributes to educational programs; and
- comments, for the Chesapeake Bay scientific community, on Federal and state activities which affect research on the Bay.

## MEMBERSHIP AND VOTING

The Consortium policy is set by a board of directors. The Board consists of fifteen members. Each participating institution is represented by three members on the Board. In addition, the states of Maryland and Virginia are represented by a board member from a resource agency. The board also has one at-large member.

## BUDGET AND STAFF

The Consortium was initially funded by the National Science Foundation. Since 1977, the four member institutions have each contributed approximately 20,000 dollars annually toward operation of a central office. A director and clerical support are located at the Consortium's headquarters at the Chesapeake Bay Institute (The Johns Hopkins University) at Shady Side, Maryland. Individual projects carried out by the Consortium are funded through grants and contracts from government agencies and private sources.

## ACTIVITIES OF THE CONSORTIUM

In addition to carrying out a number of research projects, the Consortium has played a role in providing Bay-wide synoptic analyses. Examples include the conduct and publication of a major symposium on the effects of Tropical Storm Agnes on the Chesapeake Bay and organization of a Bi-State Conference on the Chesapeake Bay which focused on five "problem areas" and also upon improved coordination and management of the Bay. More recently, the Consortium has conducted a thorough analysis of the research progress that has been made to date in the understanding of the Bay, and has attempted to define the priority research needs for the next decade.

SECTION 5

# THE CHESAPEAKE BAY RESEARCH BOARD AND OFFICE FOR CHESAPEAKE BAY RESEARCH COORDINATION

## INTRODUCTION

The Chesapeake Bay Research Board (independent) and Office for Chesapeake Bay Research Coordination (within the U.S. Department of Commerce) were created by P.L. 96-460, the Chesapeake Bay Research Coordination Act of 1980. The Act recognizes that the Chesapeake Bay area is one of the greatest national resources in the United States -- an abundant source of seafood, recreation, beauty, and enjoyment, and also a major commercial waterway. It also recognizes use-related problems in the Bay, including water pollution, shore erosion, and sedimentation. Numerous Federal agencies are studying these problems, and there is a need for coordinating various study efforts. Coordination among the efforts of various Federal agencies was the prime concern of the state and the commonwealth in jointly backing this legislation.

## GEOGRAPHIC SCOPE

The act defines the Chesapeake Bay area as the waters of the Chesapeake Bay, including the tidal portion of its tributaries, lands within and under such waters, and the wetlands adjacent to such waters.

## PURPOSES OF THE ACT

The act identified several purposes for creating the Board and the Office, including the need to:

- provide for rational and effective coordination of research aimed at increasing the fundamental knowledge of Chesapeake Bay;
- identify key research information objectives and specify a coherent program of research to meet those objectives;
- identify needs and priorities for additional research which would improve fundamental knowledge of Chesapeake Bay;
- assure a comprehensive and balanced approach to Federally conducted and supported research on Chesapeake Bay;
- encourage the use of results and findings from research projects and other relevant information in management and decision-making concerning the Bay; and
- foster public understanding of the role of Chesapeake Bay as a unique national resource.

## DUTIES OF THE OFFICE AND THE BOARD

The Office of Chesapeake Bay Research Coordination established within the Department of Commerce is directed to carry out the following functions and services in consultation and cooperation with the Board:

- maintain a Chesapeake Bay research exchange;
- review and evaluate Federal research efforts;
- make recommendations to Federal agencies concerning the relationship of their programs to the Chesapeake Bay Research Plan;
- identify the need for research programs;
- establish a mechanism for maximum utilization of available funds to benefit the Bay research effort;
- remain cognizant of on-going research efforts and assist in dissemination of research information;
- conduct routine meetings with agencies conducting Chesapeake Bay research;
- annually inventory existing research programs affecting the Bay;
- hold a Chesapeake Bay conference once every two years; and
- prepare an annual report describing research programs affecting the Bay (to the Congress, the Secretary of Commerce, and the Governors).

The Research Board is responsible for the preparation and adoption of a Research Plan which is to guide these activities of the Office. The Board is also responsible for reviewing the annual report, overseeing activities of the Office, and for providing recommendations for improving the effectiveness of the Office.

## TERM OF AUTHORIZATION

The Act is authorized for three years, after which it must be evaluated for effectiveness prior to reauthorization.

## MEMBERSHIP AND VOTING

The Board has fifteen members. Four members are selected by both the Governors of Maryland and Virginia, and seven members are selected by the Secretary of Commerce in consultation with the administrators of the Environmental Protection Agency, Secretary of the Army, the Secretary of Interior, and the Smithsonian Institution. The Board represents the interests of Federal, state, and local government, industry, the public, and the scientific and environmental communities. No voting protocol is specified.

## BUDGET AND STAFFING

The Act authorizes an annual appropriation of 500,000 dollars for the Office and calls for the appointment of a director and establishment of a staff at the director's discretion; the Secretary of Commerce is directed to make temporary staffing and administrative services available to the Office.

## ACTIVITIES OF THE BOARD AND OFFICE

Neither the Board nor the Office has been created. Funds for the Office were not appropriated in FY 1981 or FY 1982. The Governors of Maryland and Virginia wrote to the Secretary of Commerce in 1981 informing him of their selections for the Board and requesting that the Department of Commerce work with the states to carry out the intent of the Act. The Secretary of Commerce has assigned this responsibility to the Administrator of the National Oceanic and Atmospheric Administration (NOAA). NOAA is currently in the process of consulting with the other Federal agencies specified in the Act, and plans to convene the Board in the summer of FY 1982. Because of current funding constraints, it is unlikely that a fully-staffed office will be established. Thus, the focus of implementation will likely be the primary function of the Board (i.e., the adoption of a Research Plan). It has been suggested that the Chesapeake Research Consortium may be able to carry out the functions of the Office; this arrangement would, however, require some appropriation of funds. Alternately, Office functions would have to be carried out to the extent feasible by existing staff in NOAA or by any staff available to members of the Board.

SECTION 6

# THE INTERSTATE COMMISSION OF THE POTOMAC RIVER BASIN

## INTRODUCTION

The Interstate Commission on the Potomac River Basin (ICPRB) was created in 1940 by Congressional approval of the Potomac Valley Conservancy District Compact. Signatories include Maryland, Virginia, West Virginia, the District of Columbia, and the Federal government. Amendments to the Compact were ratified in 1970. The Commission is a planning and advisory group; efforts to create a regulatory and management commission similar to the Susquehanna River Basin Commission failed, despite ratification by Maryland and Virginia.

## GEOGRAPHIC SCOPE

The ICPRB is involved in the entire drainage basin of the Potomac from its up-stream reaches in the Appalachian Mountains to its mouth at Chesapeake Bay.

## PURPOSES OF THE COMMISSION

The original purposes of the Commission were to promote interstate cooperation in the prevention of stream pollution through water quality and land-use planning measures. The 1970 amendments expanded its scope to include water supply and other water-use planning.

## RESPONSIBILITIES OF THE COMMISSION

The Commission is to carry out the following water use-related services:

- interstate and basin-wide coordination;
- stimulation of Federal and state action;
- basin-wide water quality monitoring and evaluation;
- meaningful liaison with citizen and government groups;
- dissemination of information about the Potomac River; and
- provision of unique services and technical support to the Compact signatories.

## POWERS OF THE COMMISSION

In carrying out its responsibilities, the Commission may:

- conduct research and provide technical data;
- cooperate with legislative bodies and executive agencies of its members to promote uniform rules for the control of stream pollution and use of land resources;

- provide public information on water and associated land resources;
- cooperate with public and non-public agencies for planning in relation to stream pollution and use of associated resources;
- review and comment on any plan relating to stream pollution or the use of associated land resources; and
- recommend minimum treatment standards for waste discharges and physical, chemical, and bacteriological water quality standards.

## TERM OF AUTHORIZATION

The Compact is established in perpetuity.

## MEMBERSHIP AND VOTING

Each signatory has three representatives and three alternates who may vote. On important matters, however, individual delegates caucus and cast one vote per signatory. Current membership from Maryland, Virginia, and the Federal government include:

Maryland--

| Member | Alternate |
|---|---|
| Honorable Harry R. Hughes<br>Governor of Maryland | Mr. Thomas C. Andrews<br>Department of Natural Resources |
| Mr. George H. Shoemaker<br>Upper Potomac River Commission | Dr. Norton Dodge<br>St. Mary's College |
| Mr. Robert Y. Claggett<br>Upper Marlboro, Maryland | Ms. Katherine Seward<br>Bethesda, Maryland |

Virginia--

| Member | Alternate |
|---|---|
| Mr. James J. Corbalis, Jr.<br>Dir., Fairfax County Water Authority | Adm. James S. Dietz<br>Leesburg, Virginia |
| Mr. Richard N. Burton<br>Exec. Secy., VA State Water Control Board | Mr. Thomas M. Schwarberg, Jr.<br>Reg. Dir., VA State Water Control Board |
| Hon. Warren Stambaugh<br>VA House of Delegates | Hon. Dorothy McDiarmid<br>VA House of Delegates |

Federal Government--

Member

Mr. John M. Brennan
Davidsonville, Maryland

Mr. Hugh C. Newton
Alexandria, Virginia

Mr. Thomas P. Perros
Washington, DC

Pennsylvania--

Member

Honorable Kenneth J. Cole

Alternate

Mr. Walter A. Lyon

West Virginia--

Member

Dr. L. Clark Hansbarger
Charleston, West Virginia

Mr. Douglas S. Rockwell
Charles Town, West Virginia

Ms. Anne A. Eyler
Martinsburg, West Virginia

Alternate

Mr. Robert P. Wheeler
Charles Town, West Virginia

Mr. Walter Tetrick
Keyser, West Virginia

Mr. Clarence Martin
Martinsburg, West Virginia

District of Columbia--

Member

Dr. Mamadow Watt
University of the District of Columbia

Mr. William Johnson
Department of Environmental Services

Mr. Rockwood H. Foster
George Washington University

## BUDGET AND STAFFING

The Commission maintains a staff of fourteen which includes its separately funded Cooperative Water Supply Section. The Commission's offices are located at Rockville, Maryland. Appropriations from the various signatories are determined by a formula based on population and area within the basin. Maryland and the Federal government both contribute approximately 55,000 dollars, while Virginia provides about 59,000 dollars. The Commission has received additional funding through the EPA. The Commission's annual budget approximates 500,000 dollars. In addition, the Maryland Department of Natural Resources, DC Department of Environmental Protection, Fairfax County Water Authority, Virginia State Water Control Board, and the Washington Suburban Sanitary Commission (Montgomery and Prince George's Counties, Maryland) jointly contribute over 100,000 dollars to the Cooperative Water Supply Section.

## ACTIVITIES OF THE COMMISSION

The Commission has developed a Potomac Baseline Water Quality Monitoring Network. It reports to the public every two years on water quality trends in the Potomac. The Commission has developed computer modeling capabilities and analytic methodologies. Among the projects being carried out are: drought simulation, flow modeling, spill models for toxic substances, groundwater studies, and research on the effects of increased agricultural irrigation.

SECTION 7

# THE SUSQUEHANNA RIVER BASIN COMMISSION

## INTRODUCTION

Created in 1970 by an Act of Congress and by an interstate compact among New York, Pennsylvania, Maryland, and the Federal government, the Commission has a very broad mission and powers relating to the Susquehanna River basin.

## GEOGRAPHIC SCOPE

The Susquehanna River basin is defined to include all lands and waters draining into the river up-stream of Havre de Grace and Perryville, Maryland. The Compact does not give the Commission authority over the Chesapeake Bay proper. The Commission's plans and policies do, however, recognize the Susquehanna's impact on Chesapeake Bay and the need to protect the Bay's water quality and fisheries resources.

## PURPOSES OF THE COMPACT

In agreeing to the Compact, the signatories recognized the following purposes:

- to promote interstate commodity;
- to remove causes of possible controversy;
- to make secure and protect developments within the states; and
- to encourage and provide for the planning, conservation, utilization, development, management, and control of the water reasources of the basin.

## DUTIES OF THE COMMISSION

The Commission is directed to:

- adopt a comprehensive plan, after consulting with appropriate users and public groups;
- develop and adopt a water resources program based on the plan;
- adopt and promote uniform and coordinated policies for water resources conservation and management in the basin;
- administer, manage, and control water resources in all matters determined to be interstate in nature;
- assume jurisdiction in any water resource matter if necessary to effectuate the comprehensive plan and the compact;

- institute actions in state and Federal courts to compel compliance with the Compact or any rules and regulations of the Commission;
- undertake studies and investigations of the water resources within the basin; and
- give specific emphasis to the primary role of the states in water quality management.

## POWERS OF THE COMMISSION

The Commission is given very broad authority to carry out its duties, including the authority to:

- plan, acquire, construct, and operate water supply reservoirs, flood control facilities, waste treatment plants, hydroelectric facilities, land, improvements in flood plains, soil loss prevention programs, and fish and wildlife habitat protection;
- acquire land and improvements by eminent domain;
- allocate waters of the basin among the signatories;
- borrow money and issue negotiable bonds;
- regulate withdrawals and diversions of surface and ground waters;
- approve or disapprove of all water projects which involve out-of-basin diversion or which have an interstate impact; and
- enter into agreements with other river basin commissions and states with respect to diversions of water.

## TIME PERIOD AUTHORIZED

The Commission receives equal amounts of funding annually from each signatory state, presently set at 220,000 dollars per signatory, or a total of 880,000 dollars; however, New York currently provides only 90,000 dollars. A staff of twelve is headed by an Executive Director and is located in Harrisburg, Pennsylvania.

## MEMBERSHIP AND VOTING

The Governor of each member state and an appointee of the President of the United States (generally the Secretary of Interior) make up the Commission membership. Each member appoints an alternate with voting privileges. Current members are as follows:

| Member | Alternate |
|---|---|
| Honorable Hugh L. Carey<br>Governor of New York | Mr. John A. Finkrath<br>Chief, Interstate Water Section<br>NY Dept. of Env. Conservation |

Nicholas De Benedictis
Secretary, Department of
Environmental Resources

Mr. R. Timothy Weston
Assoc. Dept. Secy. for Resources
Mangagment
PA Dept. of Environmental Resources

Henry Williams
Department of Environmental
Conservation

Mr. James G. Watt
Secretary of the Interior

Mr. Warner M. Dupuy
Department of the Interior

## ACTIVITIES OF THE COMMISSION

Tropical storms Agnes and Eloise caused major flooding damages in the Susquehanna River basin shortly after enactment of the Compact. Much of the Commission's efforts since then have been directed toward flood-plain management and mitigation of flooding damages. The Commission has recently become heavily involved in water supply issues through the development of a water-use data system, adoption of a Water Conservation Policy, and development of a low-flow management or drought emergency plan.

Two issues of particular interest to Chesapeake Bay managers include anadromous fisheries and water quality. In 1981 the Commission adopted a "Strategic Plan for Restoration of Diadromous Fishes of the Susquehanna River Basin" which includes recommendations for fish passageways around four hydroelectric dams on the lower Susquehanna to encourage passage of shad, alewife, herring, striped bass, and American eel, and possibly assist in up-stream stocking of some anadromous species. The Commission has also become involved in water quality management through nonpoint source sampling programs and evaluation of low flows in the lower Susquehanna during peak operation modes at Conowingo Dam. The Commission is working together with the EPA's Chesapeake Bay Program on nonpoint source studies and analysis of nutrients at the four hydroelectric plants.

The Commission is currently embroiled in court proceedings concerning the relicensing of the Conowingo Dam and Hydroelectric Facility. In 1980 the Federal Energy Regulatory Commission granted a new fifty-year license for the facility without adopting conditions developed by the Commission regarding fish passageways and low-flow requirements. As a result of court proceedings, fish passageway and low-flow requirements may be inserted into the FERC license at some future data. The necessity of judicial settlement of this controversy demonstrates that intergovernmental cooperation cannot be assured, even by an authoritative agreement such as the Susquehanna River Basin Compact.

SECTION 8

# THE POTOMAC RIVER FISHERIES COMMISSION

## INTRODUCTION

Created in 1958 by an Interstate Compact approved by Congress, the Commission has authority to regulate fishing in the Potomac River. The Compact recognizes the ownership of the river by Maryland and the rights of both Maryland and Virginia citizens to access the river's waters and harvest its fisheries.

## GEOGRAPHIC SCOPE

The Commission's jurisdiction is limited to the tidal portion of the river from the District of Columbia to the mouth of the river between Point Lookout, Maryland and Smith's Point, Virginia. Along the shores of the river, jurisdiction extends to the low water mark on either shore, but excludes the creeks, coves, and tributaries to the river.

## PURPOSES OF THE COMPACT

The Commission is expected:

- to recognize the respective ownership, riparian rights, and rights of access of the two states and their citizens to the beds, waters, and fisheries of the Potomac River; and
- to carry out necessary conservation and improvement of the tidewater portion of the Potomac River fishery resource through a Commission composed of representatives of the two states.

## DUTIES OF THE COMMISSION

The Commission is directed to carry out the following tasks:

- survey oyster bars;
- conduct research relating to the conservation and repletion of the fishery resources; and
- issue licenses for the taking of finfish, crabs, oysters, clams and other shellfish; and license vessels and equipment used for such taking by citizens of both states.

## POWERS OF THE COMMISSION

The Commission is empowered to carry out the following activities in pursuit of its mandate:

- reseed and replant oyster bars;
- prescribe by regulation the type, size, and description of all species of finfish and shellfish and the places and methods in which they may be taken;

- contract with scientists and agencies for research;
- purchase, borrow, lease, or construct needed equipment and facilities;
- expend funds, receive grants, establish license fees, and impose inspection taxes; and
- establish rules and regulations for meetings, hearings, and internal administration.

## TIME PERIOD OF AUTHORIZATION

No procedures or data for termination were included in the Compact.

## MEMBERSHIP AND VOTING

The Governor of each state appoints three members to the Commission. Two members from each state constitutes a quorum. Adoption of rules and regulations by the Commission requires public notice and a public hearing; such regulations are subject to amendment or recision by joint action of the Maryland and Virginia General Assemblies.

Current membership of the Commission includes:

| | |
|---|---|
| Mr. John T. Parran, Jr. | (Charles County, Maryland) |
| Mr. Francis J. Russell | (St. Mary's County, Maryland) |
| Mr. L.E. Zeni | (Administrator, Tidewater Administration, Maryland Department of Natural Resources) |
| Mr. William Pruitt | (Virginia Marine Resources Commission) |
| Mr. R. Wayne Browning | (Associate Member, Virginia Marine Resources Commission) |
| Mr. Ivan D. Mapp | (Asso. Member. Virginia Marine Resources Commission) |

## BUDGET AND STAFFING

The Commission currently receives 150,000 dollars from each state for a total appropriation of 300,000 dollars. In addition, the Commission funds much of its operation through license fees and inspection taxes. A staff of four headed by an Executive Secretary is located at the Commission's office in Colonial Beach, Virginia.

## ACTIVITIES OF THE COMMISSION

The major activity of the Commission is the regulation of commercial fisheries harvest in the Potomac River and replenishment of those fisheries. From time to time, the Commission also reviews and comments, from the standpoint of protection of the productivity of this fishery, on activities that may impact the water quality of the river.

SECTION 9

# THE ATLANTIC STATES MARINE FISHERIES COMMISSION

## INTRODUCTION

The Atlantic States Marine Fisheries Compact (ASMFC) was adopted by several states in 1941 and authorized by Congress in 1942. Currently member states include: Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, and Florida. The tidal waters of the Atlantic Coast to the three-mile limit of state jurisdiction are within the ASMFC area of concern. Membership is limited to coastal states and contiguous states that are visited during an anadromous fish migratory cycle.

## PURPOSES OF THE COMPACT

The purposes of the Compact are to:

- promote the better utilization of the marine, shell, and anadromous fisheries of the Atlantic seaboard;
- develop a joint program for promotion and protection of the fishing industry; and
- prevent the physical waste of the fisheries from any cause.

## DUTIES OF THE COMMISSION

The Commission is directed to:

- make inquiry and ascertain methods, practices, circumstances, and conditions that would enhance conservation and prevent waste of Atlantic seaboard fisheries;
- draft and recommend legislation dealing with conservation of Atlantic Seaboard marine and anadromous fisheries;
- present proposed legislation to the Governors of states in which the Commission recommends it be enacted at least one month prior to the regular meeting of that state's legislature; and
- consult with and advise the administrative agencies of signatory states concerning problems and needed regulatory actions related to fisheries management.

## POWERS OF THE COMMISSION

The Commission is advisory but is authorized to make recommendations concerning the coordination of the exercise of the police powers from several states. In addition, the Commission makes recommendations to individual states concerning fish stocking programs and acts as a coordinating agency when two or more states are involved in a stocking program.

When two or more states agree to joint management objectives through a specific compact, the ASMFC is authorized to act as a regulatory agency. The representatives of these states act as a separate section of the Commission with powers and funding granted to it by those states. This special ASMFC section is authorized to adopt rules applicable to vessels operated by citizens of member states.

## MEMBERSHIP AND VOTING

Each member state appoints three members to the Commission. Membership is reserved for the head of the state agency charged with marine fisheries conservation, a member of the legislature designated by the committee on interstate cooperation of that state, and a citizen with knowledge and interest in marine fisheries. Citizen representatives are appointed by the Governor of each state.

Current members from Virginia and Maryland are:

| Virginia | Maryland |
|---|---|
| Mr. William Pruitt<br>Marine Resources Commission | Mr. L.E. Zeni<br>Administrator, Tidewater Administration |
| Hon. Theodore V. Morrison, Jr.<br>Virginia House of Delegates | Hon. R. Clayton Mitchell, Jr.<br>Maryland House of Delegates |
| Mr. Carl Croasdale<br>Governor's Appointee | Mr. August Berlitz<br>Governor's Appointee |

Action by the Commission requires an affirmative vote from the majority of the whole membership of compact states present at the meeting. Recommendations concerning a given species of fish require an affirmative vote from the majority of compact states demonstrating an interest in that species.

The National Marine Fisheries Service is designated as the primary nonmember research agency for the Commission and is directed to send representatives to the Commission's meetings. The Commission is also required to form and consult with an advisory committee of commercial fishermen and salt-water anglers.

## TERM OF AUTHORIZATION

The Compact remains in effect and binding on each signatory state until renounced. Renunciation or a state's declaration of withdrawal must be preceeded by six months written notice to all other signatory states.

## STAFF AND FINANCING

The Commission's 1982 budget requests totaled approximately 120,000 dollars. Maryland and Virginia contributions are 8,300 dollars and 11,800 dollars, respectively. Another 370,000 dollars in assistance is provided by the National Marine Fisheries Service. The total annual budget is approximately 490,000 dollars. The Commission maintains offices for six staff members, headed by a director, in Bethesda, Maryland.

## ACTIVITIES OF THE COMMISSION

The Commission is working on or has adopted management plans for several species important in Chesapeake Bay, including striped bass, Atlantic menhaden, summer flounder, shad, and river herring.

The Commission is also involved in coordinating efforts under the Fisheries Management and Conservation Act for management of species using the waters beyond the three-mile limit of state jurisdiction -- the fisheries conservation zone -- and is actively involved in reviewing and commenting on Federal fisheries legislation.